

5-18-2010

Economical and environmental aspects of spontaneous combustion in Kosovo open mining process : [presentation given May 18, 2010]

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American University in Kosovo Master of Science Degree Program
In Professional Studies with Service Management
& Infrastructure Development Concentration

Capstone Project

**Economical & Environmental Aspects of
Spontaneous Combustion in Kosovo's
Coal Mining Process**

Bashkim Lushtaku

Submitted as a Capstone Project in partial fulfillment of a Master of Science Degree Program in Service Management and Infrastructure Development Concentration at the American University in Kosovo.

List of Contents

Abstract.....	5
CHAPTER 1	
1.0. Introduction	6
1.1. Kosovo coal basin.....	6
1.1.1. Geology of basin.....	7
1.2. Current exploitable fields	10
1.3. Potential coal fields.....	12
CHAPTER 2	
2.0. Problem background.....	13
2.1. Current state.....	17
2.2. Methodology in use.....	18
2.3. Finding for future by reviewing past.....	19
2.3.0. New technologies.....	19
2.3.1. New approach.....	21
2.3.2. Engaged teams.....	22
2.4.1. Detection of spontaneous combustion.....	23
2.4.2. Monitoring of spontaneous combustion	25
2.4.3. Preventing of spontaneous combustion	27
2.5. Spontaneous combustion.....	29
2.5.1. Problem approach	29
2.5.2. Applying New technology	30
CHAPTER 3	
3.0 Economics	34
3.1 Geo Technical Profile I-I South East Sibovc (affected area)	35
3.1.1 Geo Technical Profile II-II South East Sibovc	36
3.1.2 Geo Technical Profile III-III South East Sibovc	37
3.2 Estimation related with coal loss due to spontaneous combustion.....	38
CHAPTER 4	
4.0 Environmental issues as a consequence of spontaneous combustion.....	41
4.0.1 CO_2 emissions Mine & Power plant.....	42
4.0.2 CO_2 Measurements in mine	43
4.0.3 CO_2 Measurements Prishtina.....	45
4.0.3 Estimated CO_2 emissions in Power plant	46

CHAPTER 5

5.0 Other states affected from spontaneous combustion process.

5.1 China	48
5.2 United States of America.....	49
5.3 Germany.....	49
5.4 Lessons learned.....	50

CHAPTER 6

6.1. Conclusion & Discussions.....	51
6.2 .Recommendations.....	54
Appendix	55
List of references.....	56

List of abbreviations:

Sc- Spontaneous combustion

CO₂ –Carbon dioxide

MEM-Ministry of Electricity and Mine

KEK- Kosovo Electricity Corporation

PP- Power plant

Qt- Total coal value

Cp- Cumulative price

WHO-World Health Organization

Ppm- part per million

Contents of Map

Map .1.	Kosovo Coal Basin's	6
Map .2.	Kosovo Geological Map	8
Map .3.	Kosovo Coal Basin current state	10
Map .4.	Coal seam thicknesses in Kosovo coal Basin	11
Map .5.	Situation Map	28

Contents of figure.

Fig .1.1.1	Stratigraphic Standard Profile in Kosovo Coal Basin	9
Fig .2.0.	Old Methodology in prevention of spontaneous combustion	13
Fig .2.0.1.	New Methodology in prevention of spontaneous combustion	13
Fig .2.0.3.	Oxidation, coal ranking	15
Fig .2.0.4.	Coal Triangle	16
Fig .2.1.	ESH-a dragline in activity	17
Fig .2.2.	Direct Spontaneous Combustion fighting	18
Fig .2.2.1	Excavation of local burning	18
Fig .2.3.1.	Vario Camera	19
Fig .2.3.2.	Hand Camera	19
Fig .2.3.4.	Grouting System	20
Fig .2.3.5.	Drilling System	20
Fig .2.3.6.	Flow chart	21
Fig .2.3.2.0	Infra red images	23
Fig .2.4.2	Monitoring of spontaneous combustion process	25
Fig .2.4.3	Sample of infra red images	26
Fig .2.4.4	Management Information System	26
Fig .2.5.2.	Geotechnical Section South East Sibovc	31
Fig .2.5, 3	Process of injection (training sample)	32
Fig .2.5.4.	Structural profile South East Sibovc	33
Fig .3.0	Affected area from spontaneous combustion section I-I	35
Fig .3.1	Affected area from spontaneous combustion section II-II	36
Fig .3.2	Affected area from spontaneous combustion section III-III.....	37
Fig .4.1	CO ₂ Power plants and mine	42
Fig .4.2	Gas monitoring	43
Fig .5.0	Greenhouse gas USA	49

Contents of Table.

Tab .1.0	Lignite reserves in Europe	7
Tab. .2.0	Development stage of the process	14
Tab. .2.0.1.	Relevant factors to be considered	16
Tab. .2.3.2.	Differences old VS new methodology	22
Tab. .2.4. 1.	Spontaneous combustion sample mapping	24
Tab. .2.4.3.	Basic coal properties	27
Tab .4.0.	Guide for CO ₂ level	41
Tab .4.1.	CO ₂ Levels in Coal mine Kosovo	43
Tab .4.2.	CO ₂ Levels in Prishtin	45

Abstract:

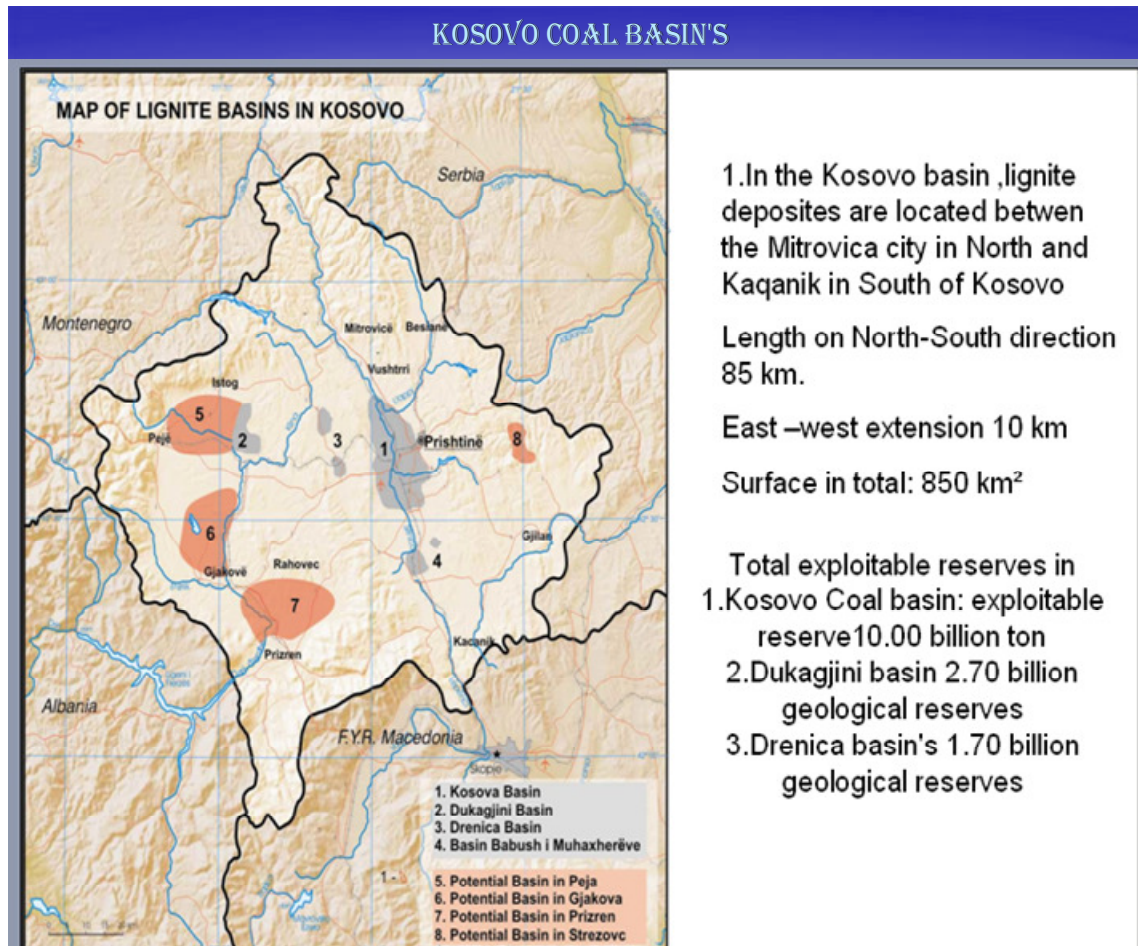
The sustainable development of Kosovo demands a huge production of electricity as one of the major issue due to the technological processes. About 97% of electricity in Kosovo is produced from Thermo Power Plants using lignite coal. A part of the processes followed from this production is spontaneous combustion and gas emission. Spontaneous combustion is an unresolved issue internationally and especially in Kosovo's open Mining Process. Spontaneous combustion as a problem in Kosovo's open Mining process is appearing in terms of both safety and economics.

This problem causes a significant annually loss of coal tonnage for Kosovo and impact on the environmental pollution because of CO_2 and other gas emissions. This is mainly caused as a result of inadequate technology and inappropriate management procedures. Spontaneous combustion is a problem which needs to be prevented not only to be solved with lignite reserves. This will be a step forward on achieving European standards related with the environment .As far as we are considering the environmental issue, during the spontaneous combustion process, approximately more then 2. 5% of total CO_2 emissions are emitted as a consequence of this process.

This project covers a new approach based on international experiences involving the four critical aspects of spontaneous combustion process: detection, monitoring, prevention and control of spontaneous combustion process in Kosovo open mining process. This capstone project considers all current data on plan making about the current mining processes and also potential Kosovo coal field, by employing new technology and new approaches. The aim is to provide an estimate benefits to the environment and economy.

1.0 Introduction:

Kosovo is the youngest European state in West Balkan with a huge amount of natural resources, specifically coal. The most powerful potential coal reserves are dispersed in different region of Kosovo; the huge amount of those reserves is located in Kosovo basin. (Map.1) *Kosovo coal Basin's*



Source:

[4]

1.1 Kosovo coal Basin's

The Kosovo lignite mines are operating at one of the most favorable lignite deposits in Europe, due to its geological conditions, with an average stripping ratio 1.7m³ of overburden: 1t of coal. The total estimated exploitable resources of approximately 10 billion represent one of the richest lignite sources in Europe, which would allow ambitious power generation and expansion schemes for the future.

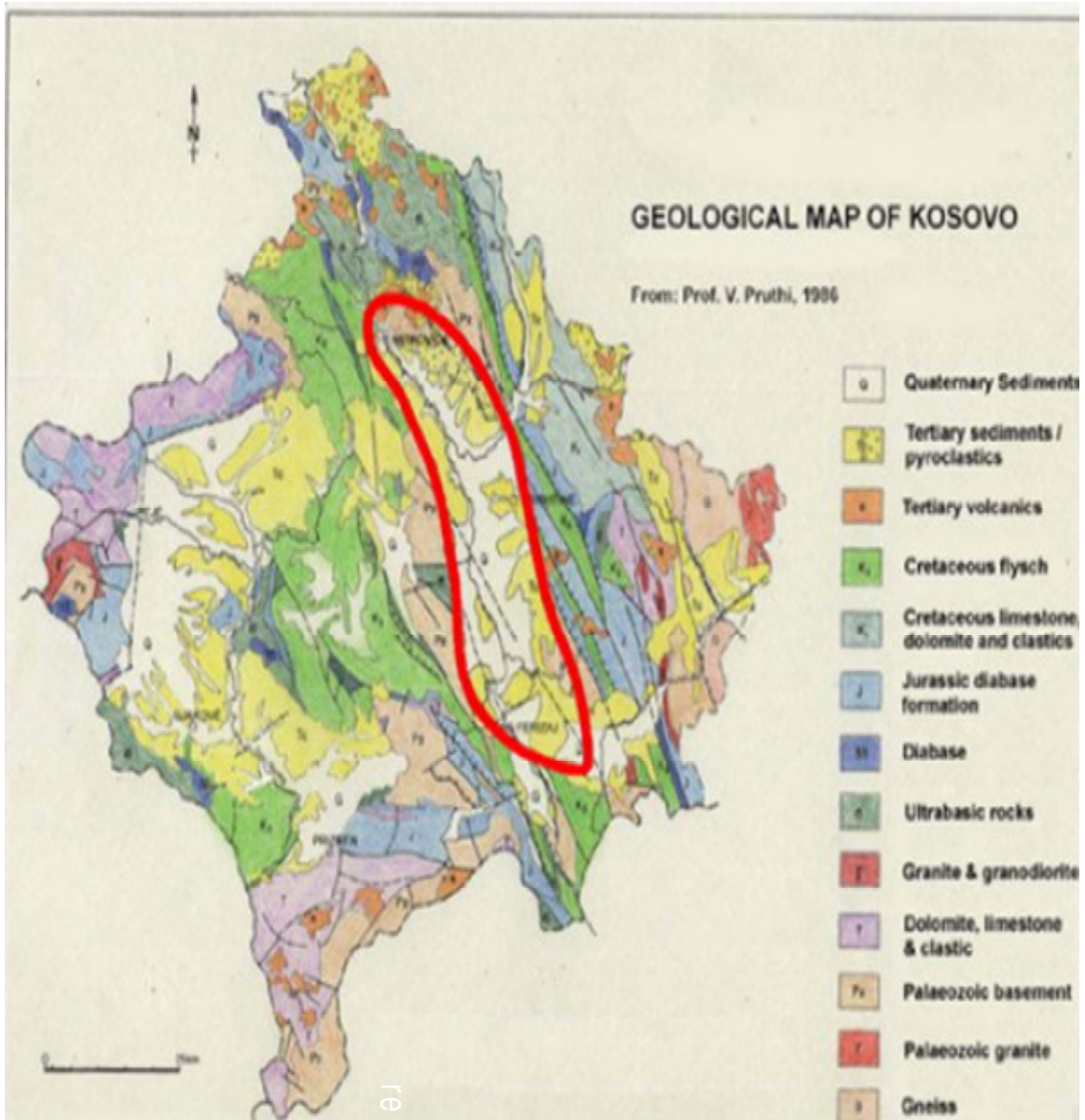
Table 1.0	
Exploatable lignite reserves in Europe	
Country	Billion/tonne
Germany	42,8
Poland	14,0
Kosova	10,0
Hungary	7,80
Turkey	5,90
Greece	4,20
Serbia	3,06
Romania	3,00
Bulgaria	2,50
Macedonia	1,70
Slovakia	0,38
Bosna and Hercegovina	0,31
Slovenia	0,15
Spain	0.04
Source:	
[16]	

1.1.1 Geology of basin.

Morphologically the Kosovo coal basins form an extended valley where the differences in elevation do not exceed 80m. Around the river Sitnica stretches a central plane part followed by a more hilly terrain nearing the mountains Çiçavica, Golesh and Sharr. The basin is surrounded by an elevated relief with Kopaunik massive, Koziç, Zhegovc, Lisic in the East, Çiçavica, Golesh Carralevo as well as Sharr Mountains in the West and North-West. The Mountains around reach elevations from 900 to 1600m

The basement of the Kosovo basin and the exposed areas are built up by Paleozoic to Mesozoic crystalline rocks. The basin fill consist of upper cretaceous strata which are uncomfortably overlain by Tertiary clays in which lignite is interceded. (map.2)

Map 2 Kosovo geology map. (Marked in red Kosovo coal Basin)



Source: Faculty of Mine

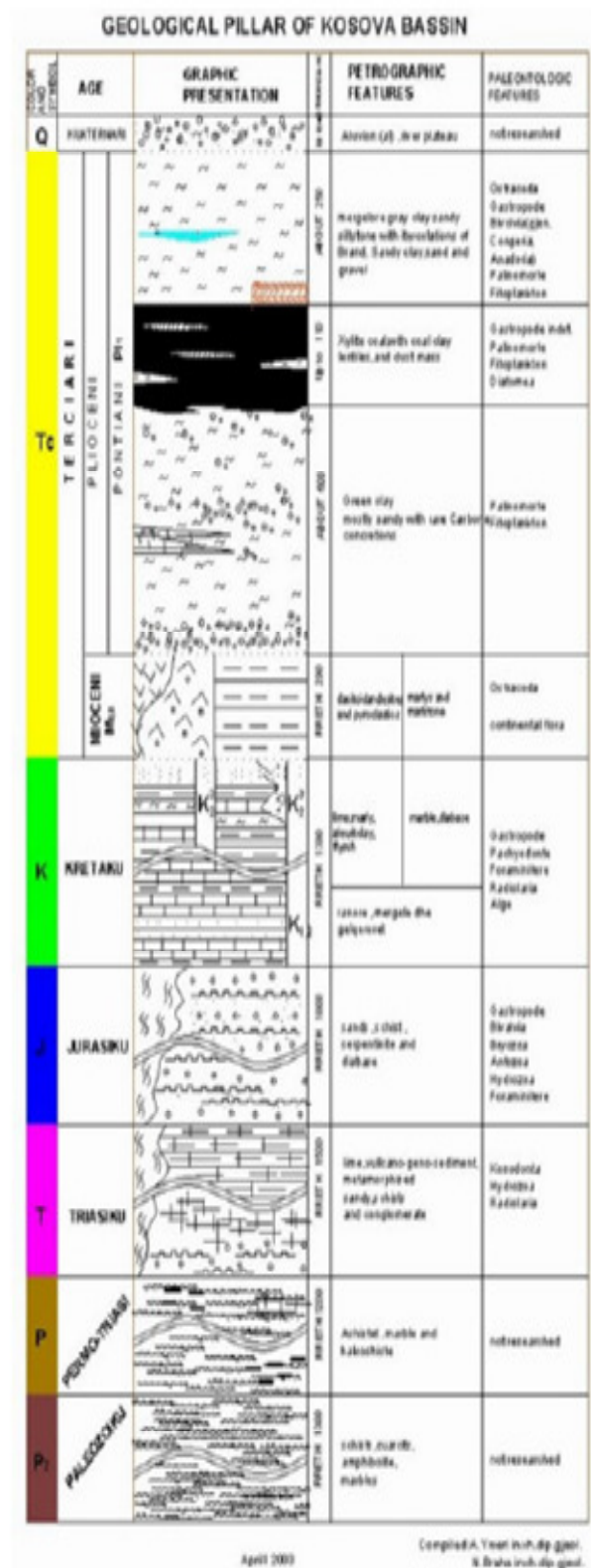


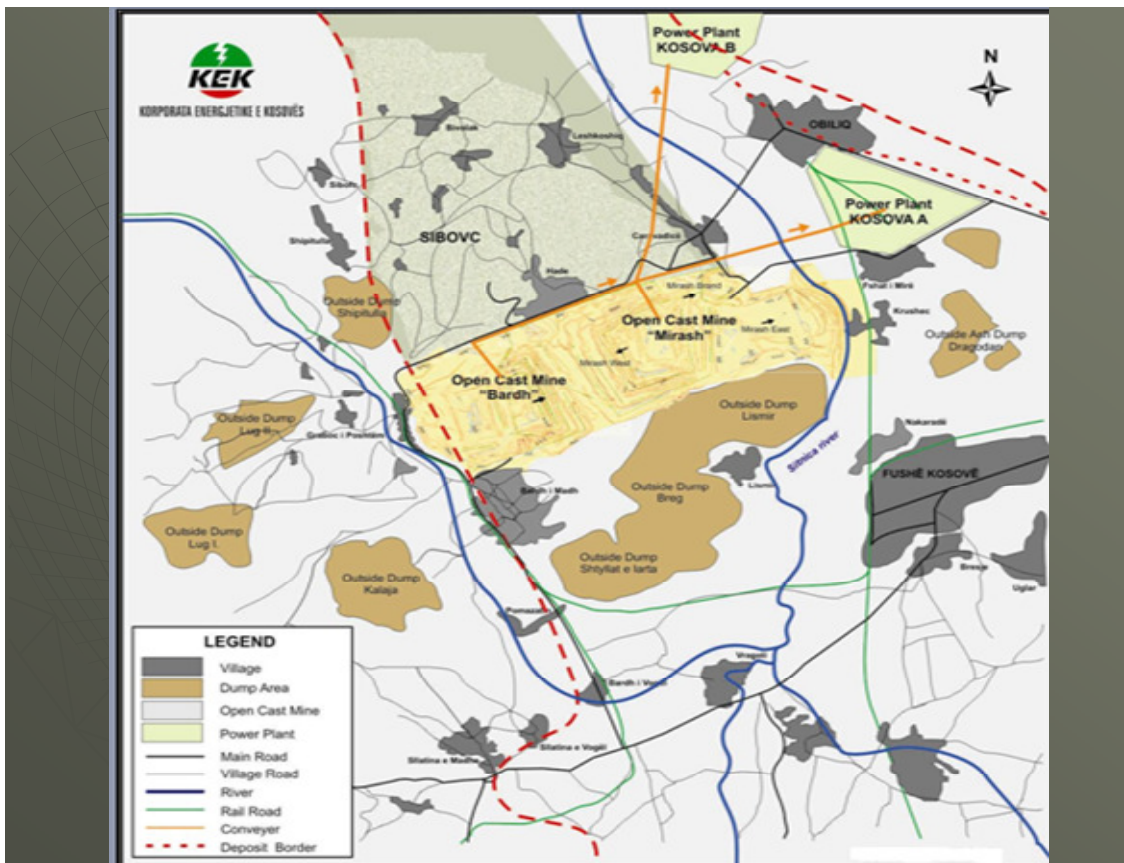
Fig .1.1.1. Stratigraphic Standard Profile of the Kosovo Basin

[KEK-2003]

1.2 Kosovo coal Basin-current state

Currently we are operating in open mines Bardh, Mirash, Sitnica East and we have already started the overburden activities in new mine South East Sibovc. All this activity is mainly oriented on supplying Thermo Power Plants A and B in Kosovo electricity system, but a part of them is used on manufacture and household activities. Using coal for electricity production we are directly contributing on environment pollution firstly by emitted CO₂ gases in to the atmosphere which seems to be on the agenda of the main concern worldwide.

Map 3. Current situation Kosovo coal Basin.

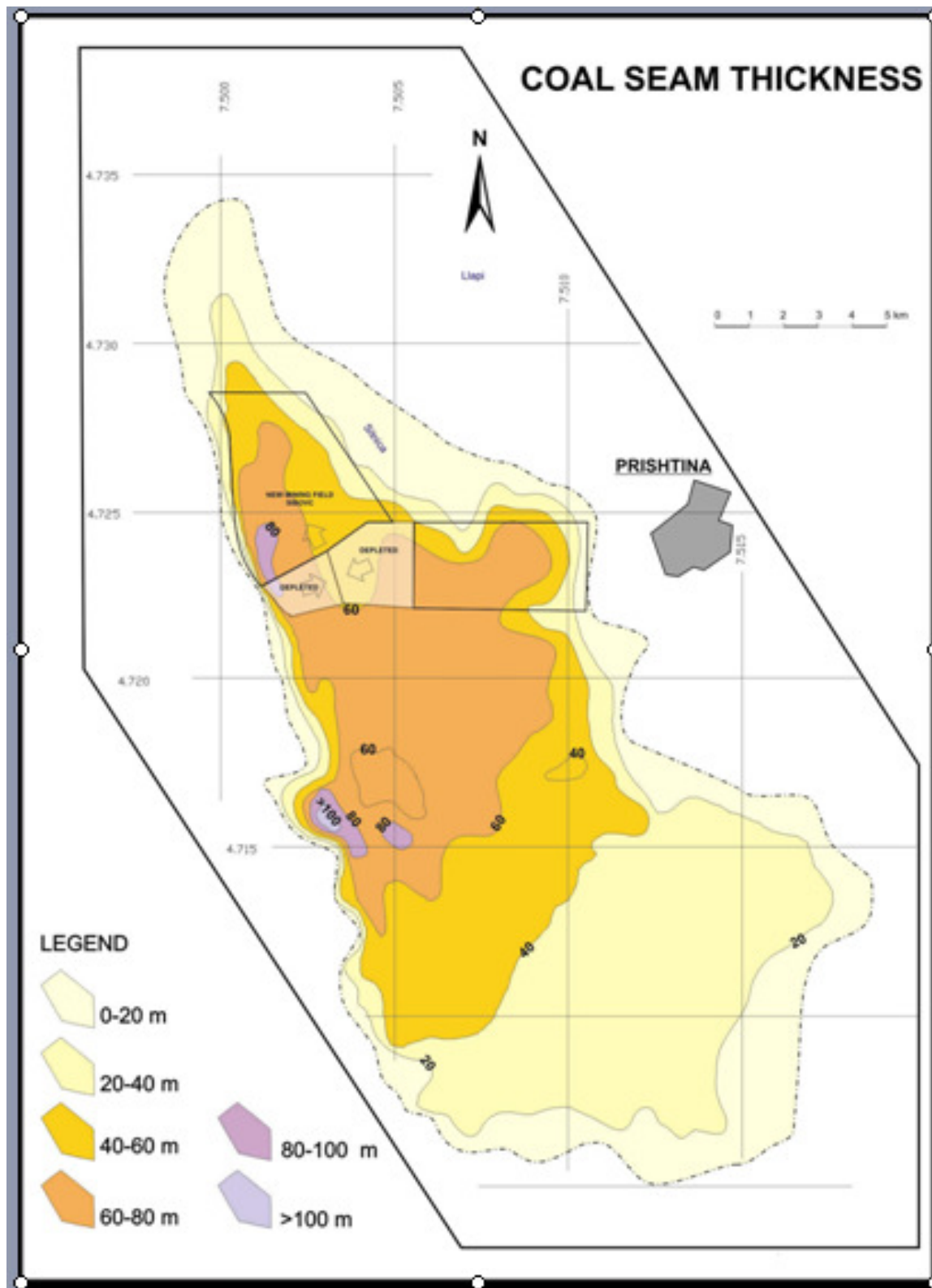


Source:

[8]

Coal seam thickness differ from the region but approximately it varies between 60-70m.in general. Dispersion of coal seams thicknesses will be shown on map 4.

Map.4. Coal seam thickness in Kosovo Coal Basin



Source:

[7]

1.3. Kosovo potential fields

Besides the Kosovo current coal fields there are identified also other potential field in Kosovo region named as Dukagjini and Drenica basin. (Map .1 positions 2 and 3). Geological researches done during the 1962-1965 does not provide a lot of information's about the above mention fields, however they could be considered as valuable potential for the future plans not only for electricity production but also for other purposes especially for domestic heating which will affect the electricity production directly because it is well known that a considered number of Kosovars use electricity for heating.

Based on the information from MEM

Dukagjini lignite basin covers about 95km² areas

- Estimated resource 2,7 billion ton of lignite
- The average calorific value 6,000-10,000 kj/kg
- The average seam thickness 32 m

Drenica basin covers about 23 km² areas:

- Estimated resource 1,7 billion ton of lignite
- The average calorific value 7300 kj/kg
- The average seam thickness 20 m

The information above has not all necessary details for the preparation of a detailed strategically decision, anyway it is a good database which could be used to identify the necessary locations and analyze the resources for long term strategy.

Based on analyses done related with lignite coal reserves in current exploitable fields it is expected that those amounts will be exhausted after 50 years ,this potential fields offer great possibilities to overtake the energy production base in domestic lignite for the period beyond.

2.0 Problem background.

At the very moment we are in the first step of opening the new mine South East Sibovc. The geological and geotechnical conditions in the Sibovc Mine will be comparable due to also existing remains of the current mining process. It is assumed that the potential danger for coal fires and CO_2 emissions will be as high as in the Bardh-Mirash mine.

Spontaneous combustion and gas emissions are not unknown processes in KEK, most of KEK employees are very familiar with them taking from the point of view its presence in environment when they work. Yearly unconsciously some of them were contributing on spontaneous combustion development, fighting against it by using water spray (figure 2.0). These experiences didn't show any significant effect on preventing it, so what is intended to be achieved by this Capstone project is to develop new methods, making plan for prevention by using new technology not only to keep the process under control but also to prevent and stop the development of this process in the future (figure 2.0.1).



Fig.2.0... Old methods, Mine Bardh.

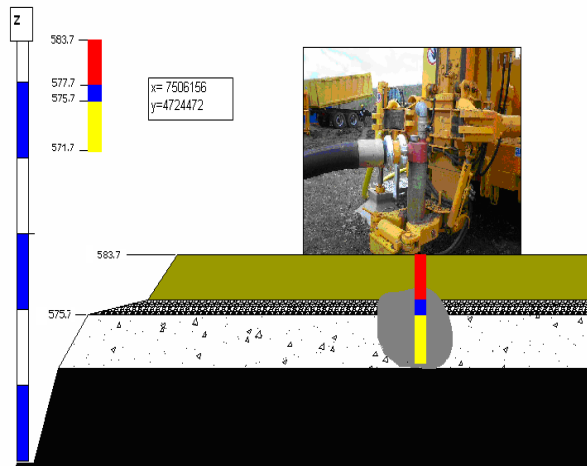


Fig.2.0.1. New method for prevention of Sc. [4]

The technology which we already possess and knowledge gained about the named issue has give as an opportunity to develop a new approach on problem solving related with spontaneous combustion.

Spontaneous combustion is process which occurs as a result from self-heating which is caused mainly by the oxidation of coal and other carbonaceous materials. Oxidation is process of change in a substance due a chemical reaction in the presence of oxygen. The process of spontaneous combustion is not going to be developed convulsively, as a process it will be developed through different stages (table 2.0.2)

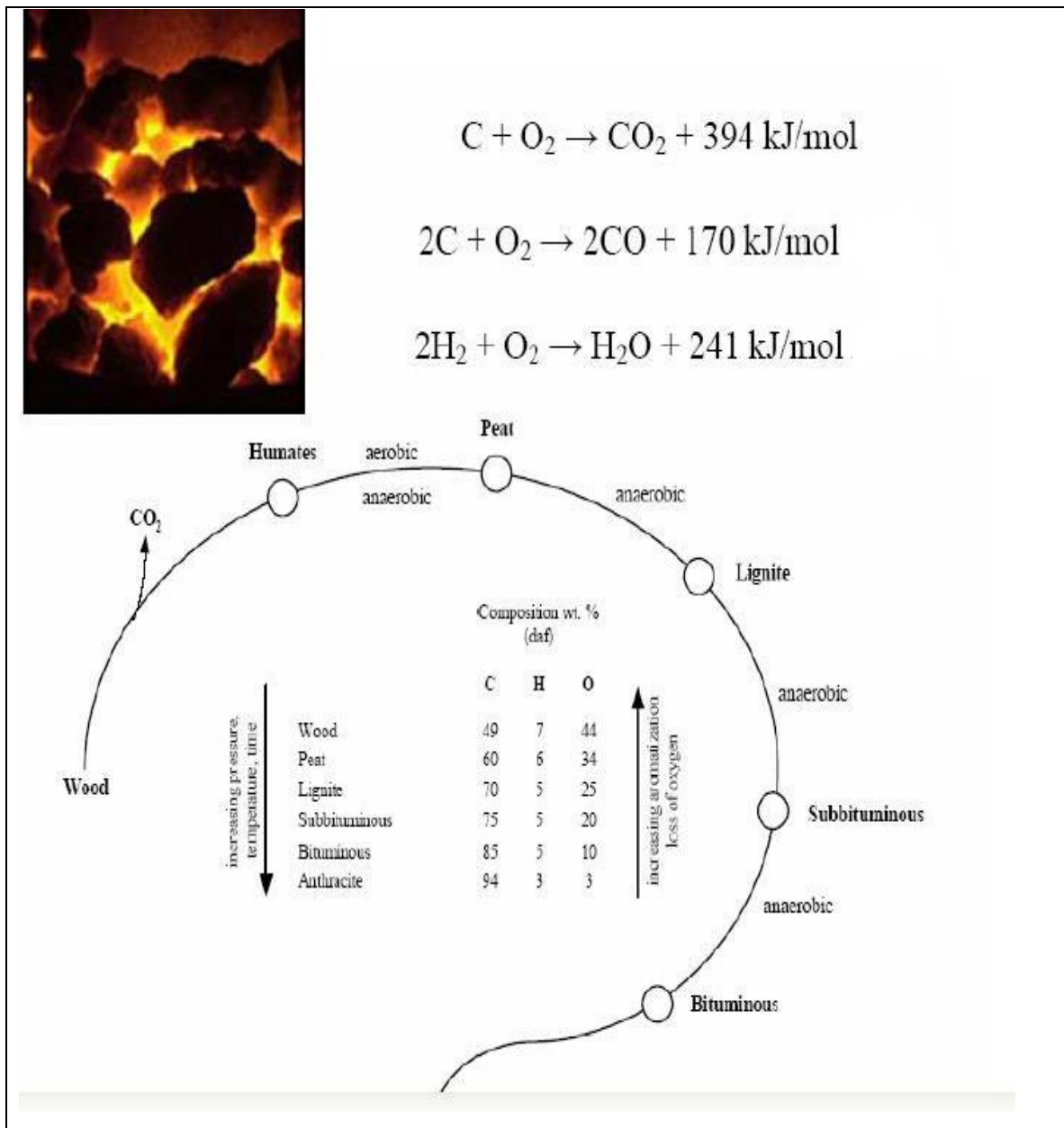
Tab 2.0.2. Development stages of process

➤ <50c° –slowly oxidation
➤ 50-80c° –incubation stage
➤ >120c° –evolutions of oxides of carbon
➤ 180-250c° –thermal disintegration
➤ 200-250c° –spontaneous combustion convulsive reaction

Source:

[1]

Fig .2.0.3. Oxidation process



Source

[1]

If the heat generated by this reaction (fig.2.0.3) is trapped, the temperature of the material will begin to rise and if unchecked may ultimately ignite. There are a different factors which directly or indirectly will impact the development of such process. But three are the main parameters due to the process of spontaneous combustion (fig.2.0.4).

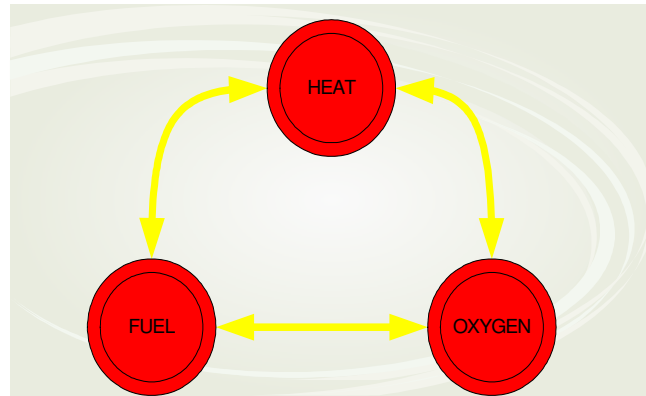


Fig .2.0.4. Fire triangle

[1]

Other relevant factors to be considered:

Table 2.0.1 relevant factors which may impact on process

Coal factors	Geological factors	Environmental factors	Mining
1. Coal reactivity. 2. Calorific value. 3. Density 4. Ash content 5. Volatile matter 6. Total sulfur 7. Friability 8 .Porosity	1. Presence of faults 2. Depth of seams 3. Floor rolls	1.Mean temperature and rain fall distribution 2.Sinkholes 3.Subsidence 4.Source of hot Spots.	1.Methods of working (opencast or underground mining) 2.Coal left at roofs and floors

Source

[2]

Process might be controlled by removing any of above mentioned parameters (fig.2.0.4) .We could reduce fuel by ventilation or water sprays but it is unrealistic to remove it all. Hence, most strategies for prevention of spontaneous combustion focus on removing oxygen or rather prevent its access in the fuel.

Very useful background information to be included on this Capstone Project will come from the courses gained during the Master's studies such as Context and Trends,

Introduction to Project Management, Breakthrough Thinking, Human Capital Strategies and Advanced Project Management. Based on knowledge gained on them a new approach on problem solving will be built, and find a reasonable and acceptable way to access on it.

2.1 Current state.

Currently in the Kosovo open mining process spontaneous combustion is predominantly controlled by old methodology such as: water spray and heavy machinery by digging and filling up the regions affected by the process.







Fig .2.1... ESH-dragline digging up and filling area under sc. effect

[KEK Mirash]

2.2. Methodology in use.

The following methods will be considered:

-  Direct fire fighting (small fires).
-  Excavation of local burning coal (hot spots).
-  Cooling with water spraying equipment.
-  Levelling of surface and drilling of injection holes.

✚ Injection of inert solutions to the fire centre.

-Direct fire fighting is a part of the old methodology but might be used in specific circumstances especially where the potential of spontaneous combustion is on small degree of risk. On these cases this methodology is preferable. Fig (2.2).



Fig .2.2. Direct fire fighting (image mine Bardh 2006)

Excavation of local burnings is to be considered where the process occurs in the front of excavation and it could be digging up by excavation with combination of cooling with water spray. (Fig .2.2.1).



Fig .2.2.1. Excavation of local burnings.

[Image KEK- Mirash Mine 2006]

2.3. Finding for future by reviewing the past.

What is intended to be accomplished with this Capstone Project is to look after acceptable methods how to make improvements by adding the new idea about problem solving; the approach which is going to be used will be based on the adage “finding for the future by reviewing the past”. If we recall the methodology we have already use on the past we will meet some significant disadvantages like land sliding as a consequence of water spray, environmental damages and most important the problem wasn’t solved in one way we just hid it temporarily. So what the new approach will show is proper way of problem treatment by using new technology and new approach.

2.3.0. New technologies.

The new technology we already possess will gave us opportunity to treat the issue as it should be treated .The technology consist from:

- Equipment for gas monitoring
- Vario Camera
- Hand camera
- Drilling system
- Grouting system

All this equipments will be shown by images in order:



Fig 2.3 Gas monitoring equipment



fig 2.3.1 Vario camera

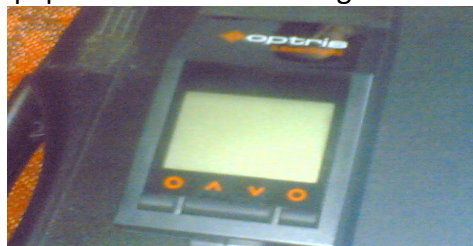


Fig 2.3.2 Hand camera



Fig 2.3.4. Grouting system

[KEK]



Fig .2.3.5. Drilling System

[KEK]

2.3.1. New approach.

New approach is going to be built mainly on methodologies learned through courses in Master Study's program at AUK. Firstly the proper flowchart is going to be drawn with main sources of problem.

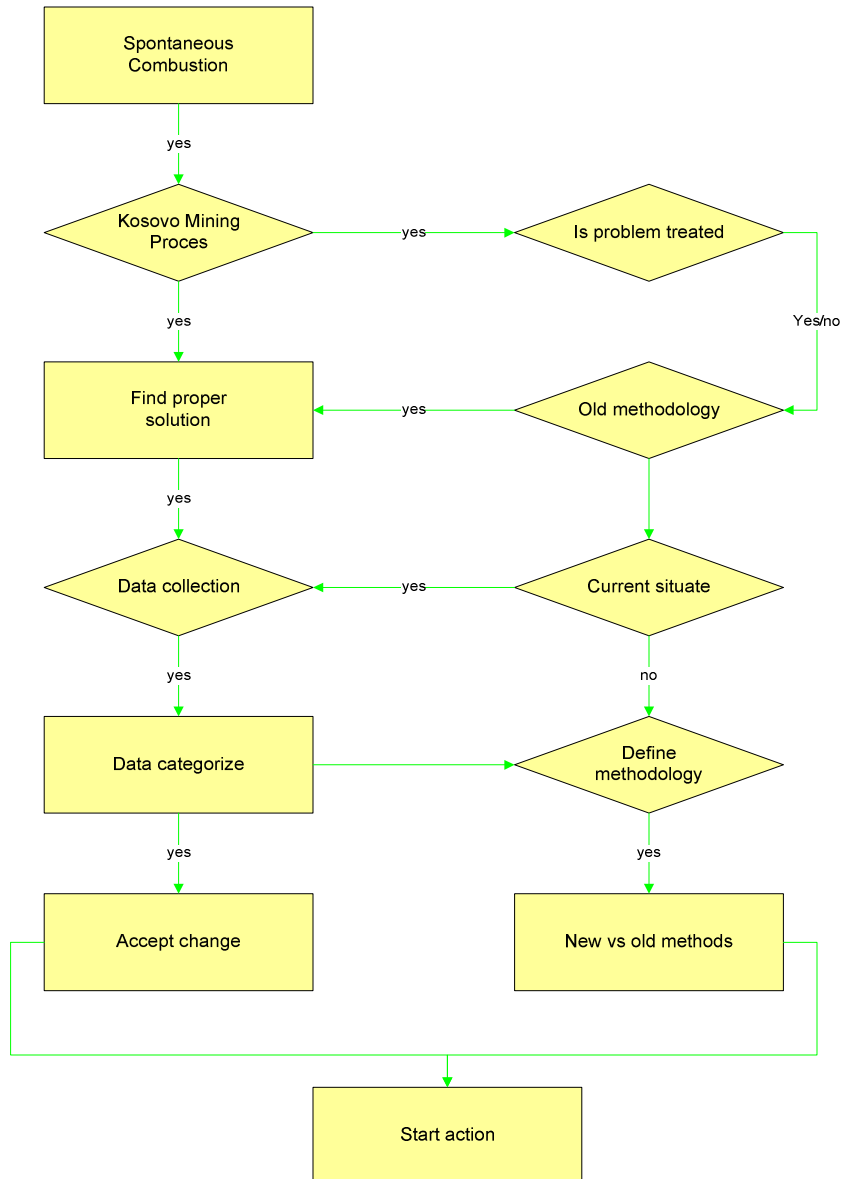


Fig.2.3.6. Flow chart spontaneous combustion process.

[7]

2.3.2. Engaged teams

The project to be fulfilled must be controlled and monitored by engaged teams this teams will be compound from experts in different fields like Geologist, Techno log and mechanical engineer and about ten employees for both systems. Firstly the geological part of the process should be completed with aim to go forward and apply technological one. The schedule of work and methodology to be applied will be shown detailed.

The first concrete actions will be to compared with the differences between old and new methodologies (table 2.3.2)

Table 2.3.2 differences old methodology VS new one.

Process	Old methodology	VS	New methodology
Detection	Visual		Infra red Vario cam Hand camera
Monitoring	Visual		Hand camera
Prevention	Water spray		Grouting system Drilling system
Control	Visual		Hand camera

Source

[5]

After the data has been collected the same will be used to create a useful database which is going to be used continually; it also has to be updated up to the disruptive technology through years. The function of this database will be on defining functions such are:

- ✚ Detecting,
- ✚ Monitoring
- ✚ Preventing and
- ✚ Controlling spontaneous combustion at all stages of coal production.

2.4.1 Detection of spontaneous combustion:

Early detection of process will help us a lot on finding adequate methods on fighting against these phenomena. Thanks to the European agency for reconstruction we already possess the proper technology for early detection. By using Vario cam infra red images the possibilities for detection will be much higher then it used to be when the whole process was detected only visually. Some infra red images taken in our mines will be shown on images below:

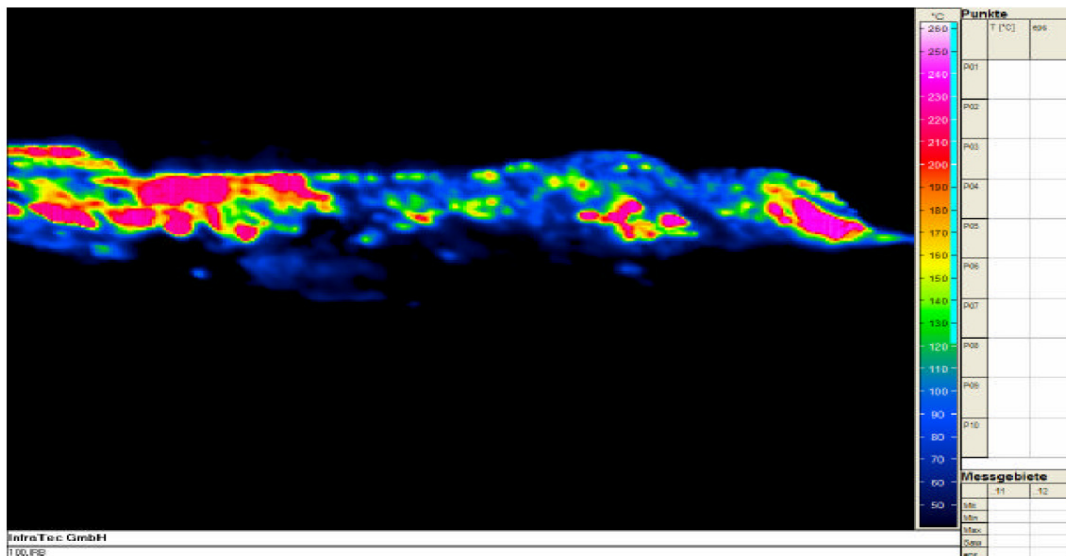


Fig.2.3.2.0. Infrared images from an area in mine Bardh. (2006)

[KEK]

As it could be seen on the image, the area colored in red represent the spaces when the process is on developing stages? Other parameters defined through the detection stages will be shown on tab (2.3.2.1).

Tab2.3.2.1 Spontaneous mapping sample mine Bard (2007).

Spontaneous combustion Mapping						
Criterion	position	position	position	position	position	position
Coordinates X (1)	723 696	723 315	723 959	724 912	723 452	723 482
Coordinates Y (1)	503 633	503 734	503 548	504 996	502 363	502 363
Coordinates X (2)	723 429	723 212		724 804		
Coordinates Y (2)	503 727	503 728		504 889		
Air monitoring						
CO (ppm)	112	3	76			
CO2 (%)	0.06	0.04	0.08			
CH4 (%)	0	0	0			
T (C°)	750	0	75	50	61-71	630
Economical. Criterion						
Irrelevant		X				
Short term						
Long term- important	X		X		X	X
Geological type						
Coal steam	X	X	X	X	X	X
Sliding block						
Coal-overburden mixture						
Low calorific value						
Geo-technical type						
Huge						
Big	X		X			X
Mid				X	X	
Small						
Burning type						
Crack related					X	X
Stockpile related						
Surface ignition				X	X	X
Environmental criterion						
Next to employee		X		X		
Potential.	mid		mid	small	mid	mid
Warnings :						

Source

[4]

2.4.2 Monitoring the process

Since the images shown that the process is on the development stages then the monitoring process should start, this process has to be done continually by using infra red thermometer which will define the differences on the temperature on different time intervals and also will be monitored the presence of indicate gasses such are CO , CO_2 , CH_4 . All those indicators will be used with aim to activate the prevention actions. The process of monitoring can be divided in two parts:

1. Acquiring data
2. Analyzing data

All the process graphically will be shown in fig 2.4.2

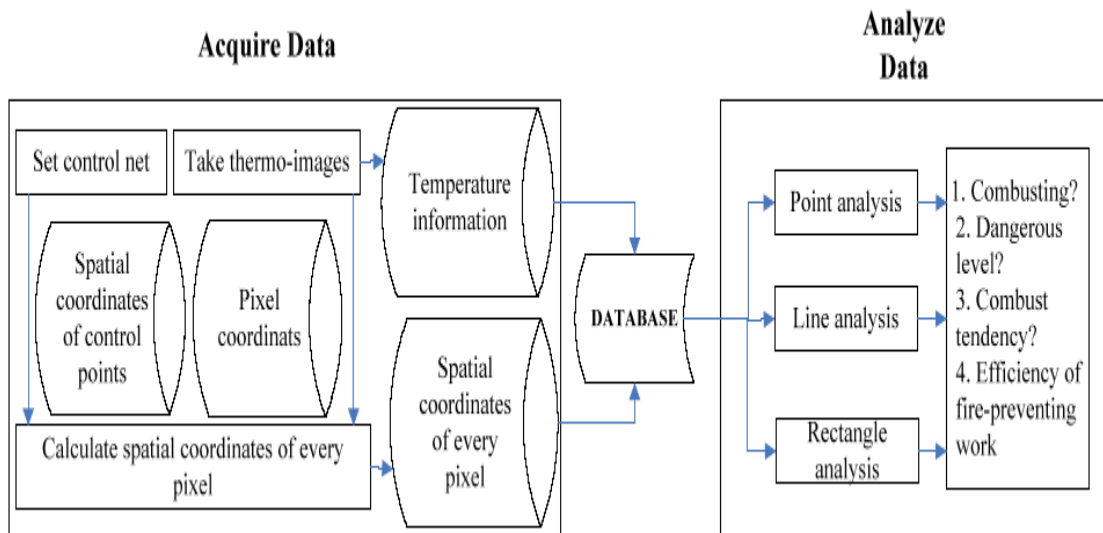


Fig .2.4.2. Monitoring of process description.

[12]

Acquiring will be based on direct temperature measurement's and thermo image analyzing all this process will be developed on computer after the collected data will be transferred into spatial coordinates. Fig.2.4.1.

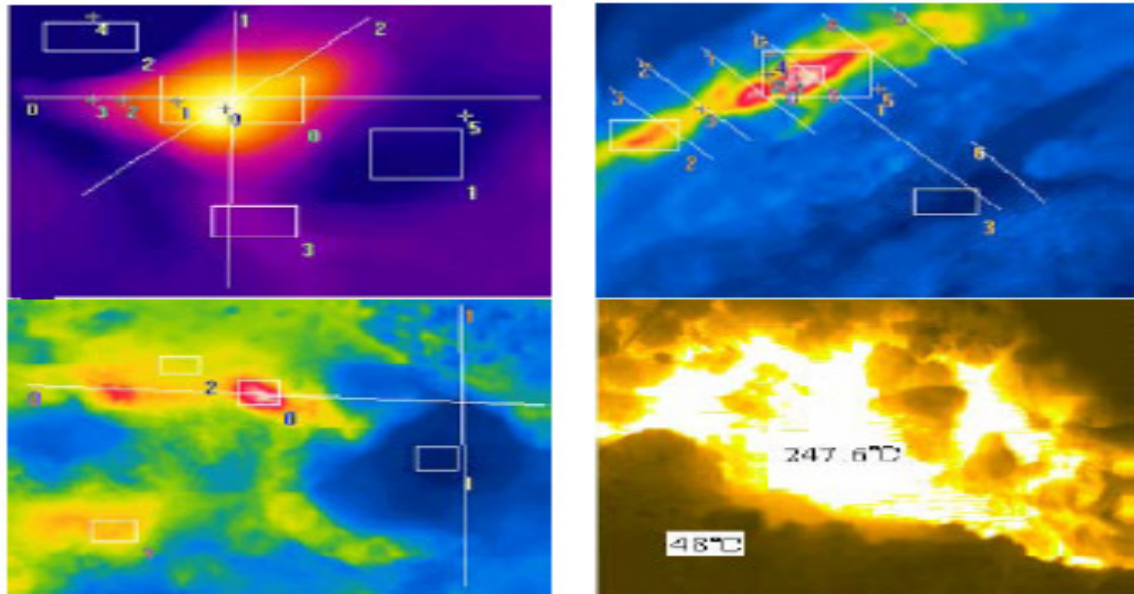


Fig.2.4.3...Sample of thermo image analyses

[12]

Compounding all above parameters; acquiring data, analyzing data a useful Management system related with monitoring will be built. Fig 2.4.4.

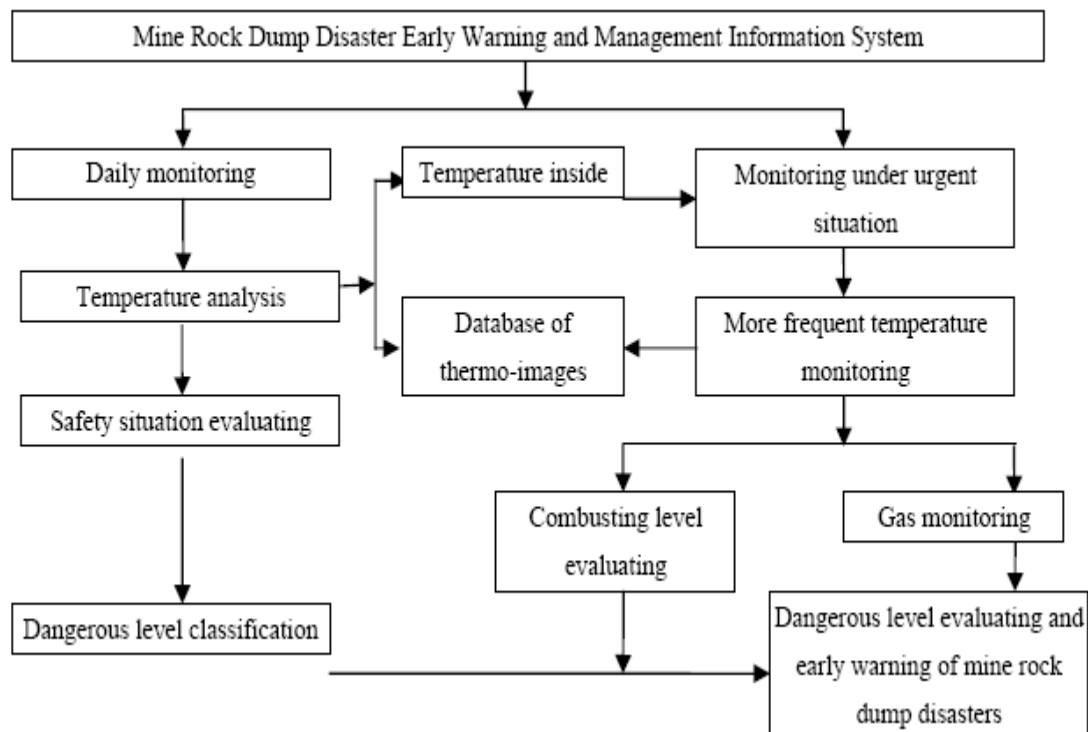


Fig .2.4.4. Management information, system-monitoring and early warning of spontaneous combustion.

[12]

2.4.3 The prevention and control of spontaneous combustion.

As a process there is not any magical word which will solve the whole issue but developing step by step procedures, starting from detection and monitoring a very useful approach could be built. Having on disposition all above mentioned information a proper methodology will be defined. In case that the power of the process is huge and risk level is evident the moment to be activated the action by using new technology is imminent.

Factors to be considered due to the preparation of project.

Coal creation is a relevant factor which is going to be used on defining geological and tectonically issue as far as, faults, cracks and fissures, and coal age. Coal physical characteristics will be used to define what are the lignite propensity level due to the spontaneous combustion process, what is the impact of physical coal properties in to the process. Because it is the fact that propensity will differ from the different ranks of coal, as higher as they are ranked the level of propensity will be decreased.

Tab 2.4.3. Basic Coal properties

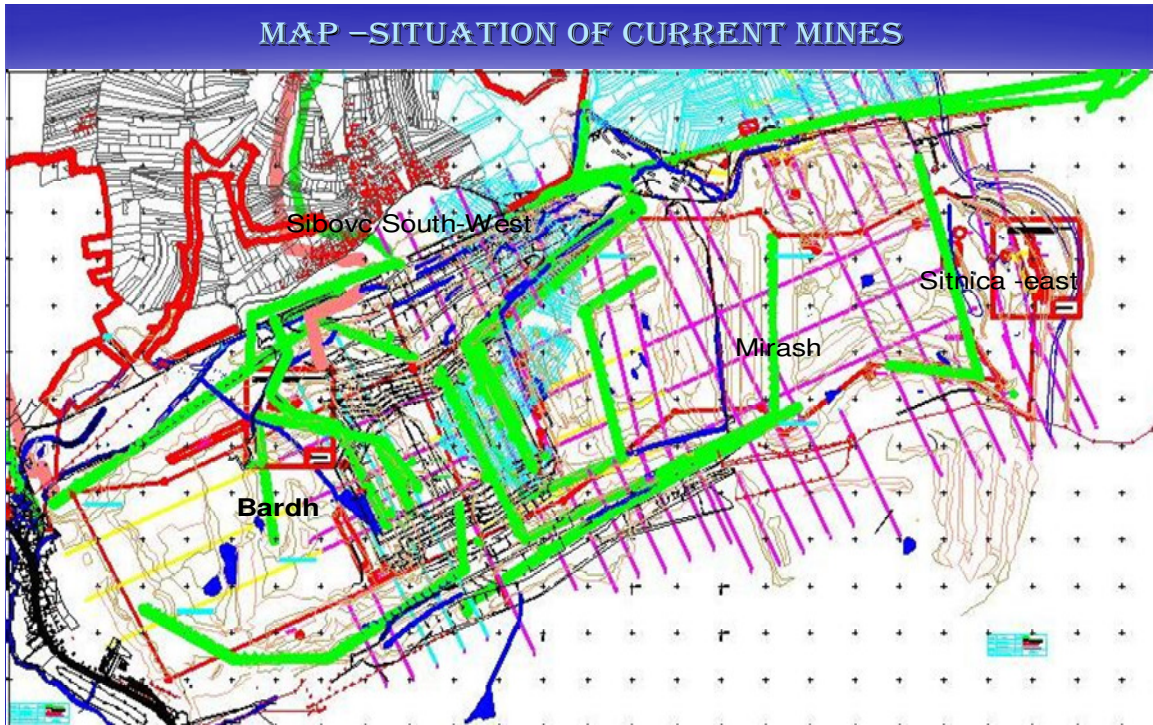
BASIC COAL PROPERTIES IN KOSOVO COAL BASIN	
Basic coal quality parameters in Kosovo Coal Basin	
Humidity [w]	38.00% - 48.00%
Ash	9.48% - 21.32%
S total	0.68% - 1.31%
S in ash	0.61% - 1.51%
S ignite	0.07% - 0.49%
Cocks	27.47% - 36.58%
C-fix	15.26% - 17.63%
HTL [High thermal level]	9663 KJ/kg.
LTL [Low thermal level]	7921 KJ/kg.
Basic coal analyses:	
Carbon	20.00%-29.56%
Hydrogen	2.01% - 2.25%
Ash analyse :	
Sio2	21.65% - 31.76%
Fe2O3	5.50% - 12.21%
Al2O3	5.95 - 9.50%
CaO	28.56 - 45.00%
MgO	2.96% - 9.00%
SO3	10.35% - 14.00%
P2O3	0.20% - 0.50%
TiO2	around 0.35%
K2O	1.50% -2.00%

Source

[KEK]

Potential current and future area will be picking up from the map situations and tectonics will be determined through longitudinal and cross sections. There is a current

map which will be used during the execution of project which will be updated in dependence of geo morphological conditions through the development of the open mining process.



Map.5. Situation map

[KEK]

Date collected from Inkos j.s.c will be using to compare different parameters from the past with present situation and with possible future actions. Different URL WebPages will be used to determine how different countries handle with prevention of spontaneous combustion, in which stage they are, are they developing similar actions.



Prevention of Spontaneous combustion in Kosovo open mining process from the very beginning must be controlled from proper staff.

2.5.1 Problem approach.

The responsible personnel should attend to the prevention of coal fires, but if they occur nevertheless the procedures for coal fire extinguishing and thus saving coal resources have to be adapted to the exploitation operations and to be done by the mines staff during the current mining activities.

Convenient extinguishing technologies have to be selected depending on the coal fire type and under consideration of the local geotechnical conditions. The extended use of water in most cases may cause land slides. Different methods will be considered to fulfil the objective of the project.

The following new methods will be considered:

-  Levelling of surface and drilling of injection holes
-  Injection of inert solutions to the fire centre

Process in which the capstone will be much more focused is Injection of inert solutions in to the fire centre. This is usually best accomplished by injecting inert solutions in the area where possibilities for spontaneous combustion process occur, this will be accomplished after the area will be firstly covered by: permanent measure of temperature using infrared camera and Vario cam depending from the geotechnical conditions ,collecting data ,drilling processes then provide adequate steps by using equipments which we posses.

Material which will be used is a combination between: fly ash, concrete, water and bentonite. The solution will be prepared in Grouting system from where the solution will be injected in by grouting and drilling system under pressure from 4- 80 bar(grouting system has a potential to inject solution with pressure started from 0-200 bar).

2.5.2. Technology of process.

- Grouting system
- Drilling system
- Fly ash
- Bentonite/concrete
- Water
- Equipment transporter

Grouting system, type Putzmaister with potential on pressure 0-200bar with all supplying system produced in Germany 2006. (Fig .2.3.4.)

Drilling system Nordmeyer (fig .2.3.5) with possibility of drillings in different angles started from 45°. Fly ash will be transported from the Power plant Kosovo B, it has to be fresh otherwise it will cause a lot of obstacles during the process. Bentonite will be delivered from external supplier. Transport will be done as a part of everyday activities from the Department of garage and transport's Department.

After the area has been defined geologically based on system of 10 drillings started on the coal seam, tectonically a lot of faults have already been defined so the purpose is to build a protection monitor with aim to stop the progress of the process in North East direction. Schematically the whole process will be described by illustrations. Firstly the geo technical section will be made as a template which will serve to lead us to the next level of process. As it could be seen a lot of cracks are present in taken profile. The point here is to take adequate steps to close these corridors to avoid the contact between air and flammable components within the terrain. Fig (2.5.2)

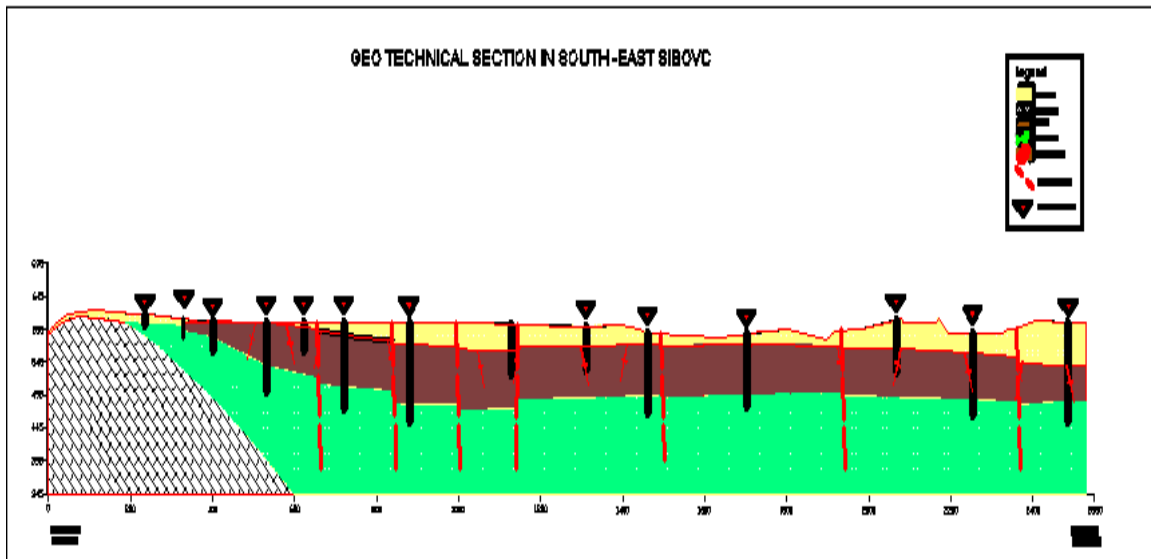


Fig.2.5.2. Geotechnical section South-East Sibovč

[KEK]

2.5.3. Main component to be compound

The rapport between the above mentioned parameters will be as followed:

Fly ash + concrete/bentonite + water

70%

20%

10%

The level of water will be calibrate during the process depending on the inside pressure of the environment when the solution will be added. Fig (2.5.3).The technological process will be developed based on step by step procedures :after the drilling has been done both systems will be connected with pipes .The calibration of parameters will be done on the control panel installed on grouting system then the material will be added to the drilling system. In the control panel and nearby the drilling system will be assessed the pressure depending from it the process might be stopped to remove the first pipe's then to continue with pumping until the pressure achieve the extreme values which are larger the 100 bar. After it the pipe system will be realized from pressure to continue with other positions. This procedure will be continuing till the all area is covered.

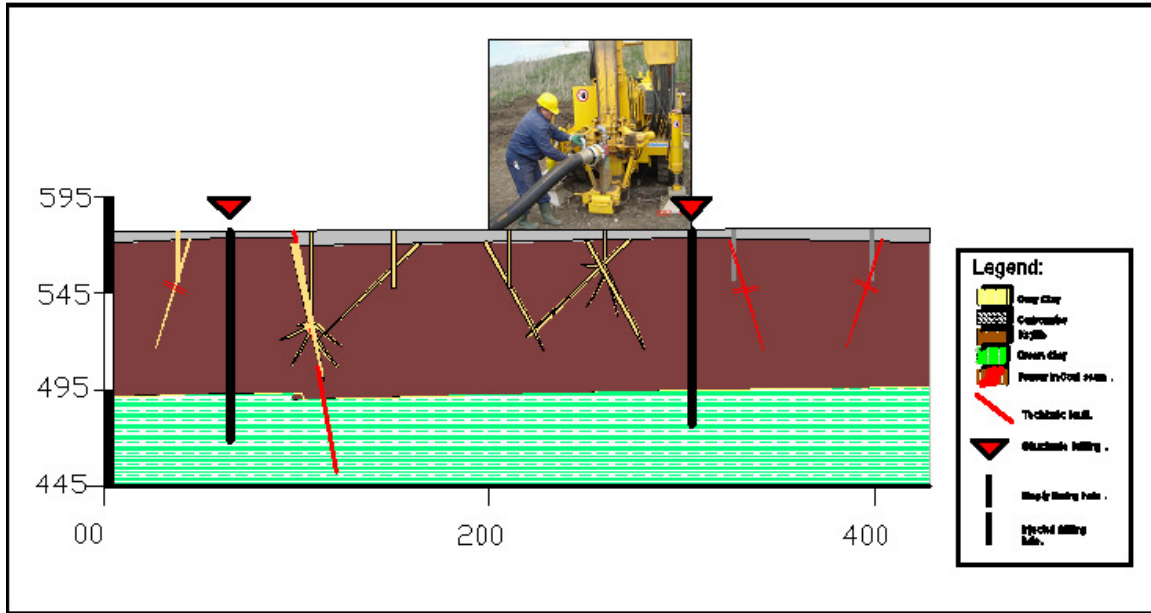


Fig2.5.3Process of injection (image taken from trainings 2006)

[KEK]

As it is shown on the scheme (fig 2.5.3) the solution will be added under controlled pressure till the moment of all fissures will be filled with solution. Closing those areas the main roads to prevent the contact between oxygen and flammable material will be done. The detailed structure profile will be shown on the pillar below.

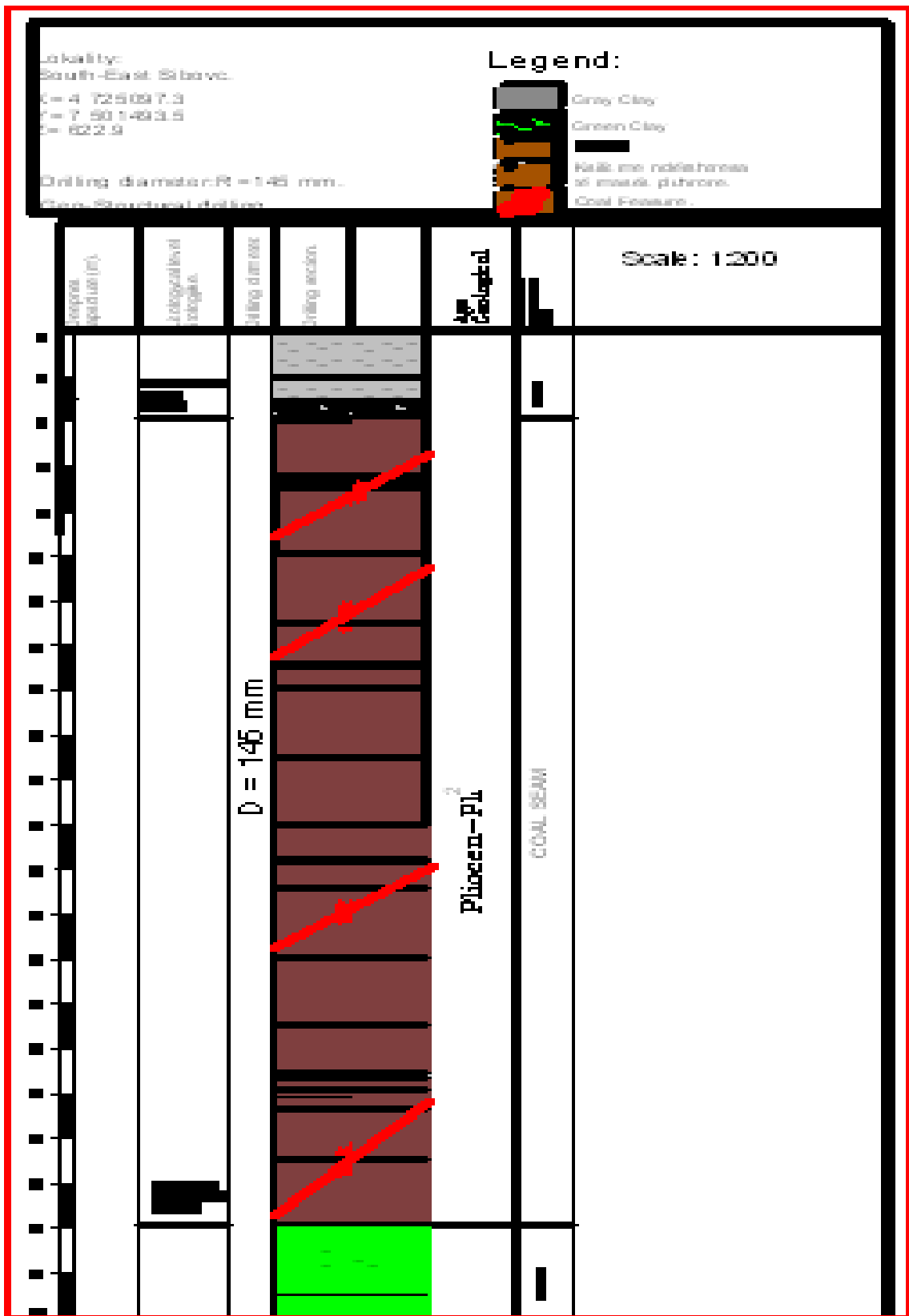


Fig.2.5.4. Structural profile South-East Sibovc

[KEK]

3.0 Economics.

The results of spontaneous combustion are serious and negative unwanted effects, undesired environmental consequence. To prevent these outcomes it has to be understood the processes that lead to runaway spontaneous combustion so that the risk can be reduced by controlling the process leading to spontaneous combustion. The economic estimation results for Kosovo economy as a consequence of the spontaneous combustion.

Based on the later analyses made from MEM and other relevant economic institutions the Kosovo have based his electricity production 97% on fossil fuel production/coal burning. Actually in the current economic term production is focused on to fulfill the domestic needs hence in long term period there are plans that it could be used for external use-export. Producing electricity from coal without having in consideration any alternative approach might fail in long term strategy even though for the moment it is the most real option strategy having on consideration not only exploitable natural resources but also the infrastructure, but this not necessarily mean to avoid other alternative's for electricity production such are win and hydro plants.

To estimate losses if the process would not be implemented the first step must start from the situation map (Map-5 pg 28) by picking up at list three longitudinal sections with aim to define the affected are.

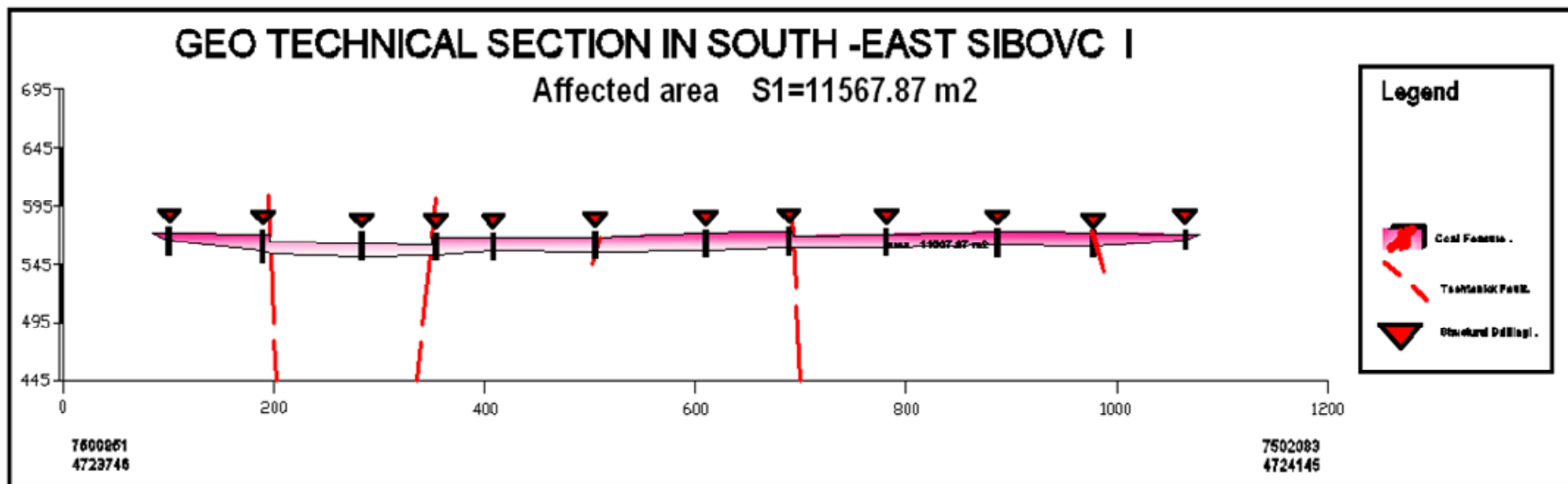
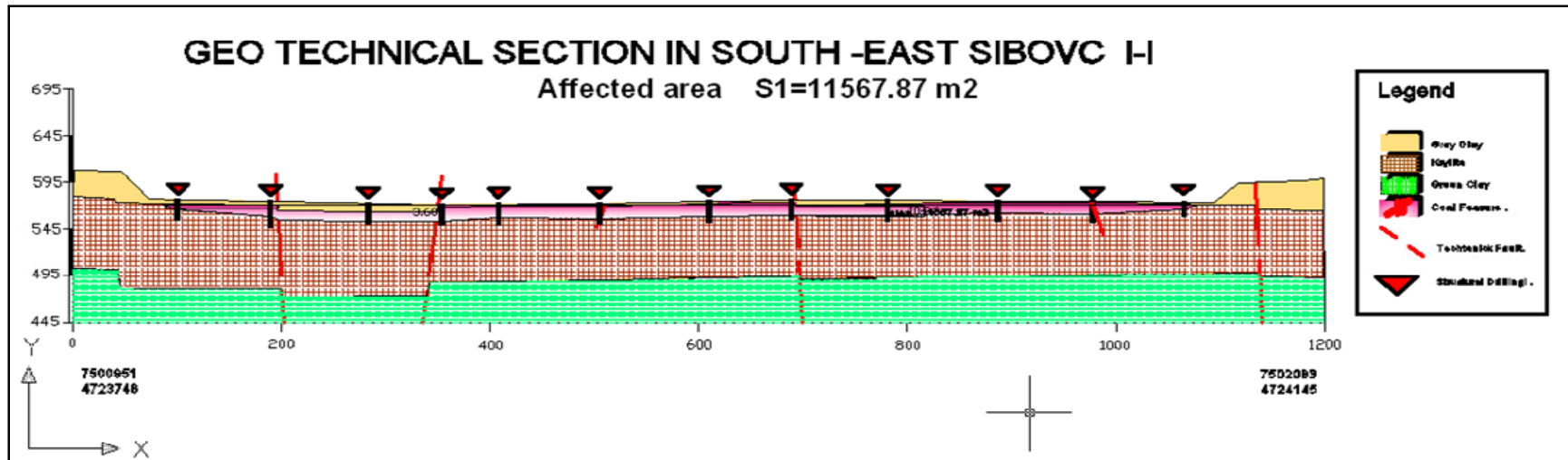


Fig 3.0 Affected area from spontaneous combustion (section I-I)

[KEK]

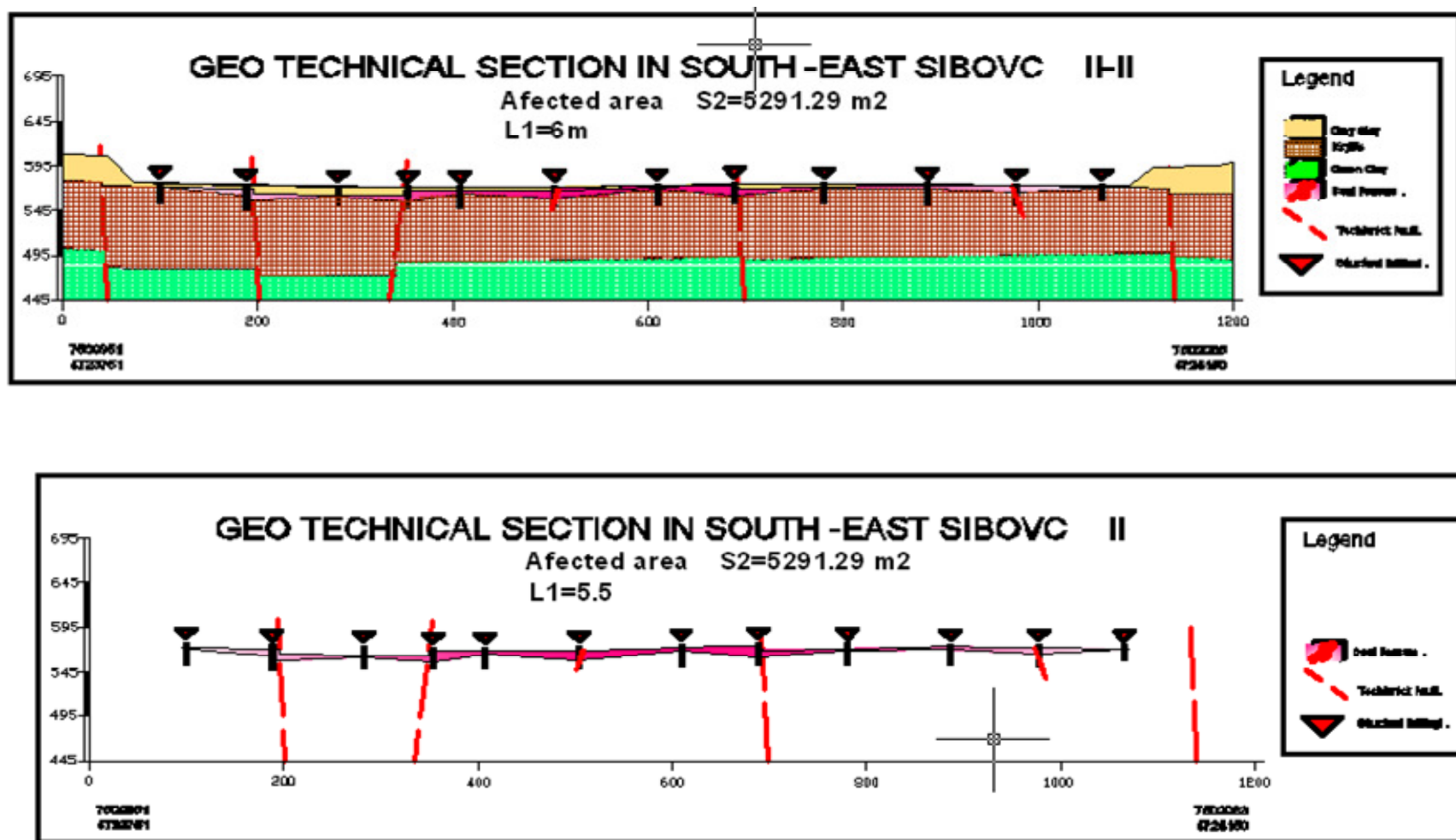


Fig 3.1 Affected area from spontaneous combustion (section II-II)

[KEK]

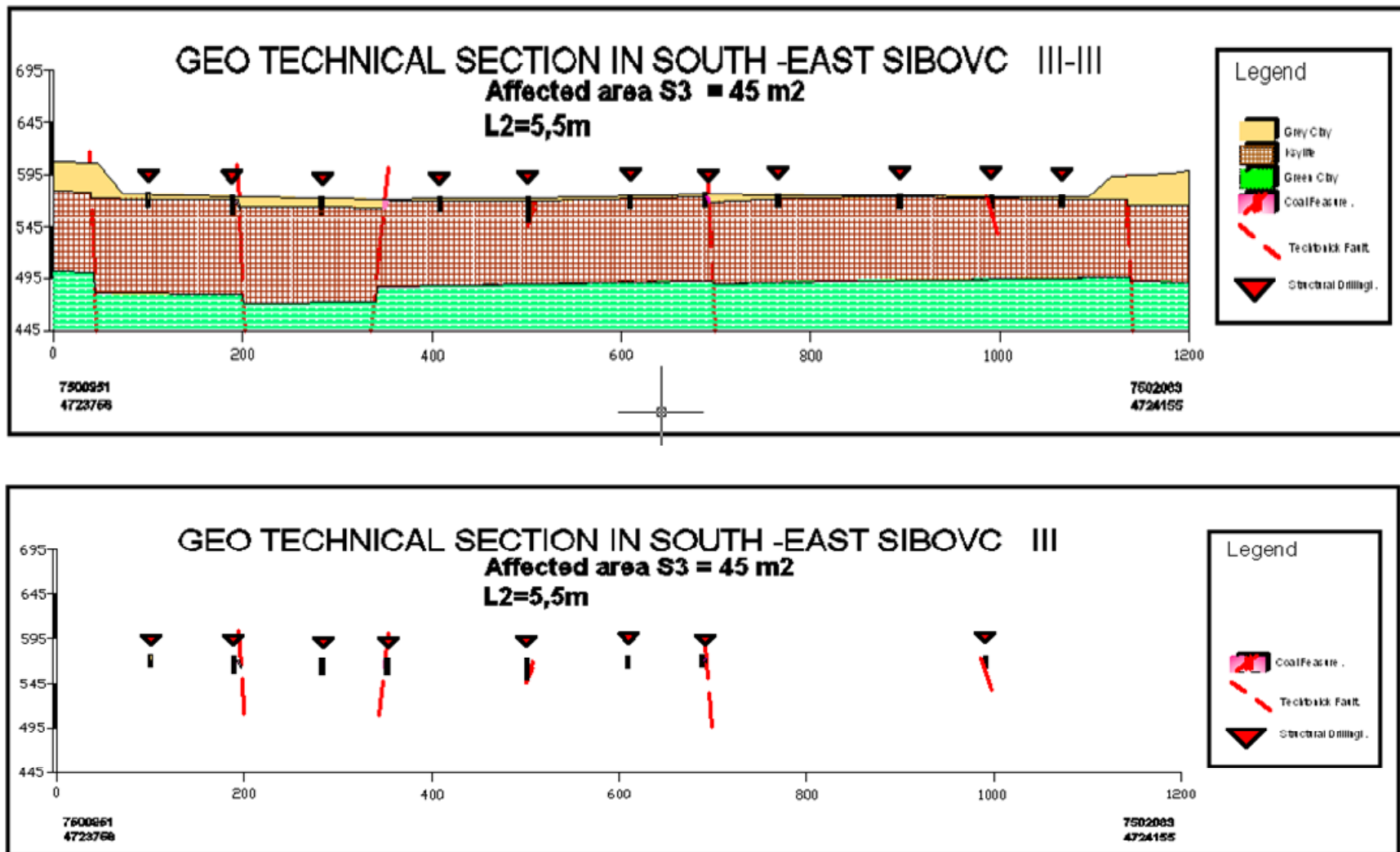


Fig 3.2 Geotechnical section III-III South east Sibovc

[KEK]

Estimation related with the amount of coal which will be loosed as a consequence of spontaneous combustion.

Geo technical profile Sibovc South –East content a graphical picture by including lit logical entities and boring holes. As it could be described through drilling holes the spontaneous effect has been met in different part of the mineral body. By using Auto CAD the surface measured is about $S_1=11567.87m^2$. To avoid assuming the other profile is done in distance about $L=5.5m$ when the surface affected seems to be large lower then the first surface, it is approximately about $S_2=5291.29m^2$ having on consideration that the development of process might be developed further another profile has been created when we met only a few little surface affected from the spontaneous combustion about $S_3=45m^2$. The distance between each profiles is $L=5.5m$. Mathematically the hole scenario about the estimation of possible coal looses is:

$$Q_1 = \frac{S_1 + S_2}{2} * L_1 * \int = \frac{11567.87m^2 + 5291.29m^2}{2} * 5.5m * 1.14 \frac{t}{m^3}$$

$$Q_1 = 8429.5m^2 * 5.5m * 1.14 \frac{t}{m^3}$$

$$Q_1 = 46362m^3 * 1.14 \frac{t}{m^3}$$

$$\underline{Q_1 = 52853.18t}$$

Q1-Total coal value between surfaces S_1 and S_2 including coal density.

$$Q_2 = \frac{S_2 + S_3}{2} * L_2 * \int = \frac{5291.29m^2 + 45m^2}{2} * 5.5m * 1.14 \frac{t}{m^3}$$

$$Q_2 = 2668.14m^2 * 5.5m * 1.14 \frac{t}{m^3}$$

$$Q_2 = 14674.8m^3 * 1.14 \frac{t}{m^3}$$

$$\underline{Q_2 = 16729.27t}$$

Q2-Total coal value between surfaces S_2 and S_3 including coal density.

The total coal amounts in affected area for three profiles are:

$$Q_t = Q_1 + Q_2$$

$$Q_t = 52853.2t + 16729.3t$$

$$\underline{Q_t = 69582.5t}$$

And after we got the total coal amount between all three profiles if we calculate with a price for coal which is about € 20 the estimation cost if we do not start the injection process only in South East Sibovc will be:

$$CP = Q_t * P_t$$

$$CP = 69582.5_t * 20 \text{ €/t}$$

$$\underline{\mathbf{CP=1. 391650\text{€}}}$$

When CP is cumulative price which we will pay if the process won't start during this year
All this data will be presented on the table 3.0

Table 3.0

Profile	Surface(m ²)		Distance (m)	Volume(m ³)		Coal Density t/m ³	Price €/t
	Separately	Average		Separately	Cumulative		
I-I	11567.87						
II-II	5291.29	8429.58	5.5	46362.7			
III-III	45	2668.14	5.5	14674.8	661037.5	1.14	20

$$CP=CV \text{ (m}^3\text{)} * \int \text{ (t/m}^3\text{)} * P \text{ (€/t)}$$

$$CP=61037.5 \text{ (m}^3\text{)} * 1.14 \text{ (t/m}^3\text{)} * 20 \text{ (€/t)}$$

$$\mathbf{CP=1. 391650\text{€}}$$

CP-total estimated price if the action will not be taken.

The total cost of the equipment in package was about €2.000.000 the payback period for it will be approximately within 2 years. If the project is going to be implemented

during 2010 in Kosovo coal open mines will be saved approximately € 1.000.000 and a significant improvement on the environment will be made.

If we decrease the level of production, CO_2 level will be decreased but it is to expect that the price for consumers will increase and the healthy environment will be built.

4.0 Environment impact caused from spontaneous combustion

Beside the economic loss ,coal fires pose many environmental threats .The fire produce large amounts of green house gases such are: CO_2 , NO_x , CO . Other consequences from this process are, Acid mine drainage and land atmospheric pollution, topsoil quality is degraded, vegetation coverage is reduced, flora and fauna habitat is destroyed and the quality of surface and ground water significantly decreases.

Producing 97%of Kosovo's electricity from lignite coal, the KEK jettisons an estimated of dust and ash in to the air every hour, 74 times the excise allowed by European Union standards. Clear size of environmental decline have existed for more than 15 years .Back in 1992 ,a report by Swedish Environmental Research group and the World Health Organization(WHO) Regional Office warned "the state of environment is critical" The root of the Kosovo's poor air quality is easy to detect ; coal mining and energy production from KEK .When the KEK plants produce at full capacity, the 200 MW units emit approximately 25 tons of dust and ash per hour, this emission include also gases such are CO_2 , CH_4 and NO_2 . CO_2 Emissions published in 2002 show that KEK CO_2 emissions were more than 4, 4 million tons annually; in this total amount the CO_2 released from the spontaneous combustion participate with more than 2% in total. According to the regulatory convents related with environmental issues the concentration of CO_2 in natural ambient is about 0.04% or 400 ppm. In general guide values for CO_2 concentrations are:

Table 4.0 General guide values for CO_2 emissions.

○	40.000 ppm	proportion in exhaled human breath (20l CO_2 /h).
○	5000 ppm	limit of CO_2 concentration at the work place.
○	> 1000 ppm	fatigue and reduced concentration.
○	1000 ppm	recommended CO_2 level of indoor air.
○	400 ppm	fresh natural ambient.

Source

[13]

The level of those values will vary from the contexts where the measurement have been done for example if we compare the area nearby Power plants in Kastriot and the area affected from the spontaneous combustion in Mine the values will be affected also from the presence of other gases .The figure below schematically describe this effect followed by chemical reaction (greenhouse effect):

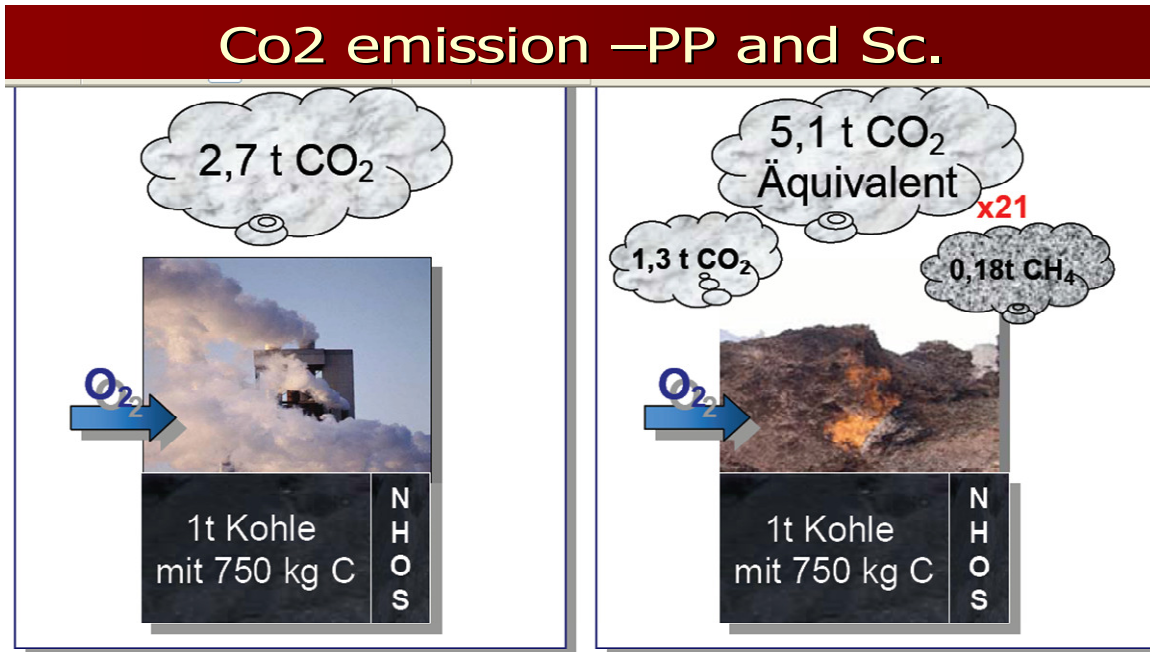
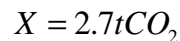
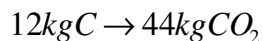
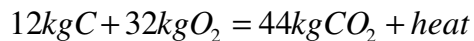


Fig. 4.1. CO₂ Emissions in Power plant and spontaneous combustion

[1]



As we might see for the same amount of coal the level of CO₂ on the air will be about 80% more this mainly about the process will be affected by uncontrolled amount of O₂. By reducing the spontaneous combustion process the large impact will be given on the environmental protection. A spontaneous combustion process is accompanied by occurrence of indicator gases such as: CO, CO₂, CH₄. This gas emission will be assessed and measured continually (fig.4.0).



Fig.4.0. gas monitoring

[2]

Data from some measurements done in 2007 will be shown on tab (4.1)

Samples from measuring in different positions in Mine Bard due to the monitoring in 2007 will be shown on table below.

Tab 4.1 Measurements of CO_2 , CO , CH_4 levels in mine Bard (2007)

Coordinate in terrain Mine Bard.	Level of CO (ppm)	Level of CO ₂ (ppm)	Level of CH ₄ (%)
X: 4.723 857 Y: 7.506 134	13	500	0
X: 4.724 168 Y: 7.506 134	130	1000	0
X: 4.724 392 Y: 7.506 088	150	800	0
X: 4.723 632 Y: 7.502 582	125	600	0
X: 4.724 290 Y: 7.506 506	130	1000	0
X: 4.724 041 Y: 7.506 563	150	900	0
X: 4.724 238 Y: 7.506 505	96	800	0
X: 4.723 559 Y: 7.506 309	70	800	0
X: 4.724 168 Y: 7.506 042	67	700	0
X: 4.724 168 Y: 7.506 134	79	800	0
X: 4.724 267 Y: 7.506 341	100	500	0
X: 4.724 302 Y: 7.505 283	112	600	0
X: 4.724 587 Y: 7.505 166	76	800	0

X: 4.724 912 Y: 7.504 996	43	500	0
X: 4.723 959 Y: 7.503 548	55	500	0

Source:

Department of engineering KEK

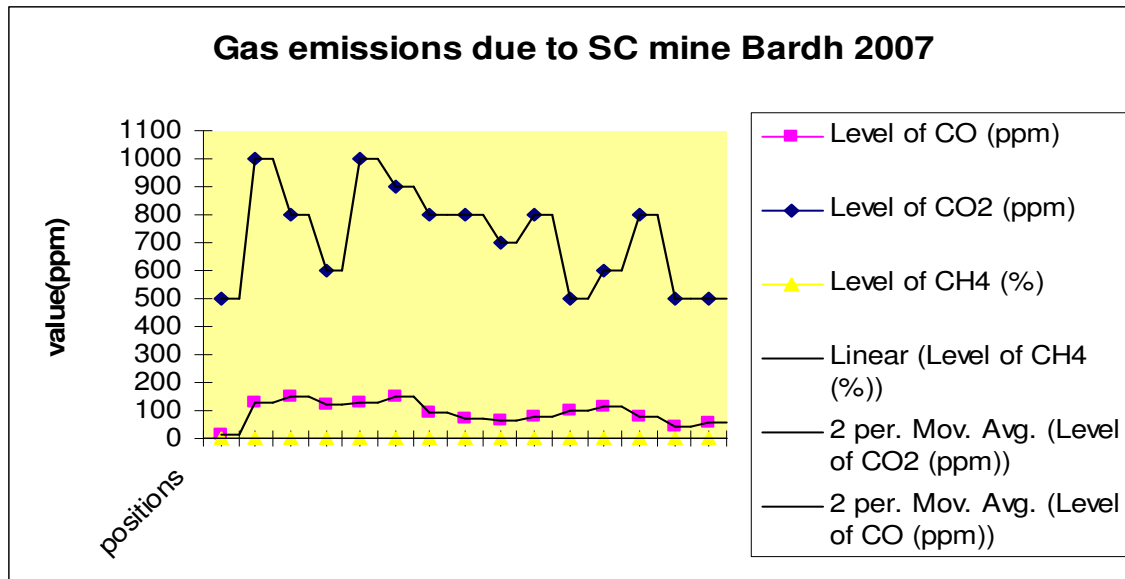


Fig 4.2

[KEK]

The measuring in mine were done with gas measurement equipment named Dräger

X-am 7000

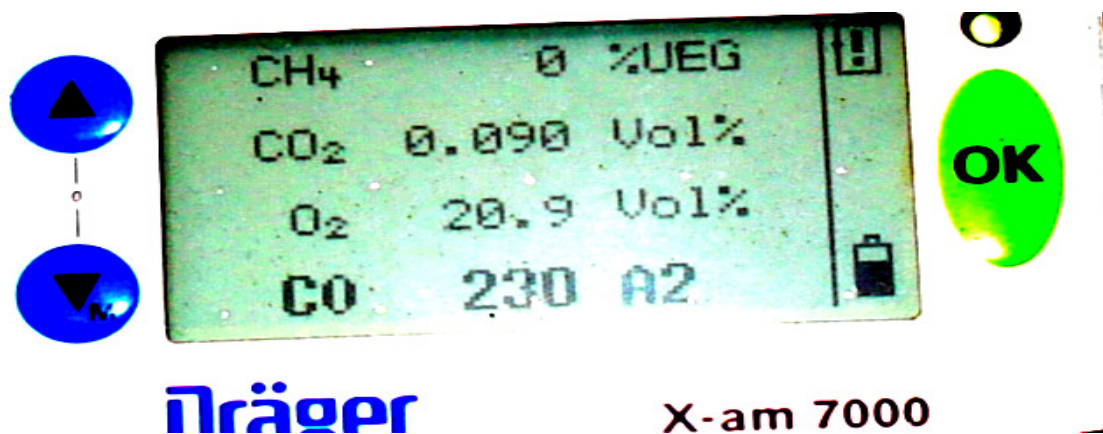


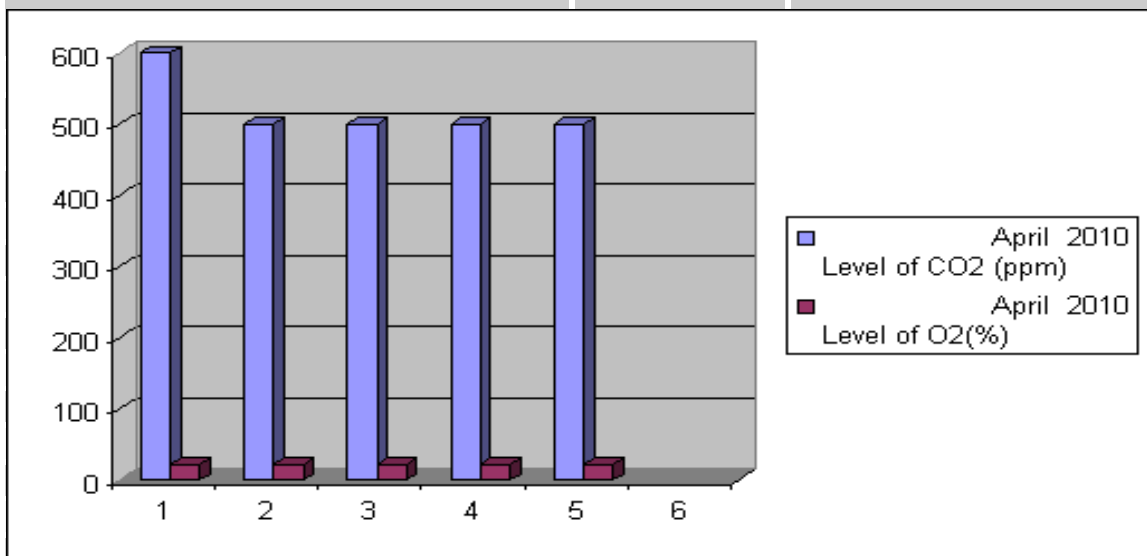
Fig 4.3 Dräger X-am 7000 (device for gas measurement) sample.

Values measured in volume % will be converted on the ppm values based for the relevant amount from example 0.090% is equivalent with 900 ppm. The measures have been done mainly in the area affected from the spontaneous combustion process.

Sample measurements of CO_2 and O_2 level in capital city in Kosovo during April 2010.

Table 4.2 Measurements of CO_2 and O_2 in Prishtina. (2010)

Measurements With Dräger x-am 7000	April 2010	
Locations	CO_2 (ppm)	O_2 (%)
1.Bill Clinton square	600	20.9
2.AUK-Prishtin	500	20.9
3.Nearby OSCE building	500	20.9
4.Toscana	500	20.9
5.Nearby Government building	500	20.9

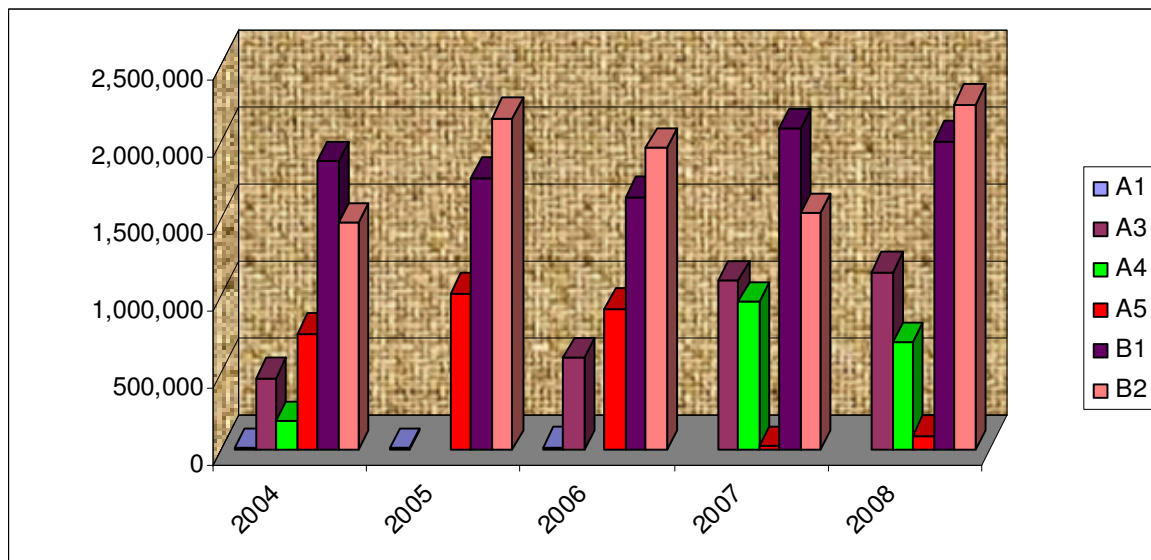


Despite the level of different gases is not on the extreme value this will affect directly in the environment pollution which will cause health hazard within the community. If we recall data will see that a large number of employees have been affected and healthy damaged from this air pollution.

Estimated CO_2 emitted as a result of electricity production using coal as a raw material in Power Plants from 2004 till 2008

Tab 4.3 Estimated CO₂ emissions in Kosovo Power Plants

Power Plants	Year Units		2004 (ton)	2005 (ton)	2006 (ton)	2007 (ton)	2008 (ton)
PPA	A1	CO ₂	5,910.000	11,831.00	19,795.00		
	A3	CO ₂	466,858.0		596,727.0	1,099.478	1,156.058
	A4	CO ₂	189,381.0			960,520.0	700,089.0
	A5	CO ₂	756,410.0	1,019,102	916,408.0	21,284.00	93,331.00
PPB	B1	CO ₂	1,876,681	1,768,446	1,646,275	2,089,314	2,009,463
	B2	CO ₂	1,477,701	2,155,334	1,962,599	1,534,868	2,245,182
TOTAL	A+B	CO ₂	4,772,941	4,954,713	5,141,804	4,607,085	5,049,221



Source:

KEK-environmental sector at the Generation division

Besides the Kosovo electricity is mainly based on coal burning Power plants the CO₂ share is not such significant comparing with other states in region or globally.

If we just take a simple analyze into the Global energy development, it is not to be expected that a fast shift from coal to another natural resources is going to appear especially in this part of Europe when potential of coal is so huge. But the new policy making on this area seems to be developed continually as an approach to decrease as much as it is possible the CO₂ emission. States in region has already started to apply

“carbon taxes” in to specific industries especial in those dealing with electricity production from coal burning.

If we recall the data related with spontaneous combustion in Kosovo case we determine the fact that annually for energy sector there are 5-7 million ton of coal reserves burning .From all this amount in the mine division approximately about 70-1,400,000 tons of coal are lost from spontaneous combustion. Estimated it means that 2-2, 5% of coal reserves are lost from spontaneous combustion the scenario of this estimation will look like.

- Estimated Kosovo burns around 5-7 million ton coal annually.
- Estimated 2-2, 5% of this emission is from spontaneous combustion.
- $7 * 10^6 \times 0,02\% = 14,000t \text{ CO}_2/\text{yr}$, with carbon tax €20-40
- Total tax will be €280,000-560,000/yr.

This tax will not affect deeply in to the budget of customer but some how will affect the consequence of those who are emitting the CO₂ without any concern. The main issue is here to convince the regulatory office of energy about the importance of this strategy.

5.0. OTHER STATES AFFECTED FROM THE SPONTANEOUS COMBUSTION PROCESS

5.1 CHINA

China is the largest coal producer (and consumer) world wide: It produces about 1.8 billion tons in 2006. As a result coal fires are a severe problem in China. It is estimated that 10-20 million tons are directly burned by coal seam fires and 100-200 million tons of coal are lost for the mining industry. The fire zones are located in a belt covering the entire north of China. According to the most recent estimation coal fires in China contribute about 0. 1-0. 2% the annual human induced CO_2 emissions globally. The economic loss of valuable resources in China is estimated to sum up to total 4. 2 billion tons since 1960. (Claudia Kuenzer 2007) If it is to consider globally China is the biggest industrial pollutant in the world sharing more then 3% of total CO_2 emissions world wide (Huang .et el 1995) The direct economic loss due to the burning coal resources in China is estimated to be about 125 to 250 million US\$ (Zhang 98).

China is the only country in the world starting and performing enormous activities for extinction. Several fires are already extinguished. New methods are developed within a Sino-German Research Initiative.

5.2 UNITED STATES OF AMERICA.

Approximately 52% of the United States electricity is generated using coal as a fuel. In 2006 coal fired Power Plants produced approximately 36% of the total United States CO_2 emissions. Many coal mining areas in the USA suffer from spontaneous coal seam fires. The Federal Office of Surface Mining (OSM) provides a data base (AMLIS) that lists 150 fire zones (1999). Those are not only in Kentucky, Pennsylvania and West Virginia in the east of the Appalachian-coal district, but also in Colorado and the Rocky Mountains. In Pennsylvania 45 fire zones are reported. The most known is Centralia Mine, in the anthracite- coal area of Columbia County. This fire burn since 1962 and develop below the city. There was some effort to extinguishing the fires but finally the city was lost.

The consequence of non adequate treating the spontaneous combustion especially from the very beginning might result with large economical negative outcome such it was the case with Centralia mine.

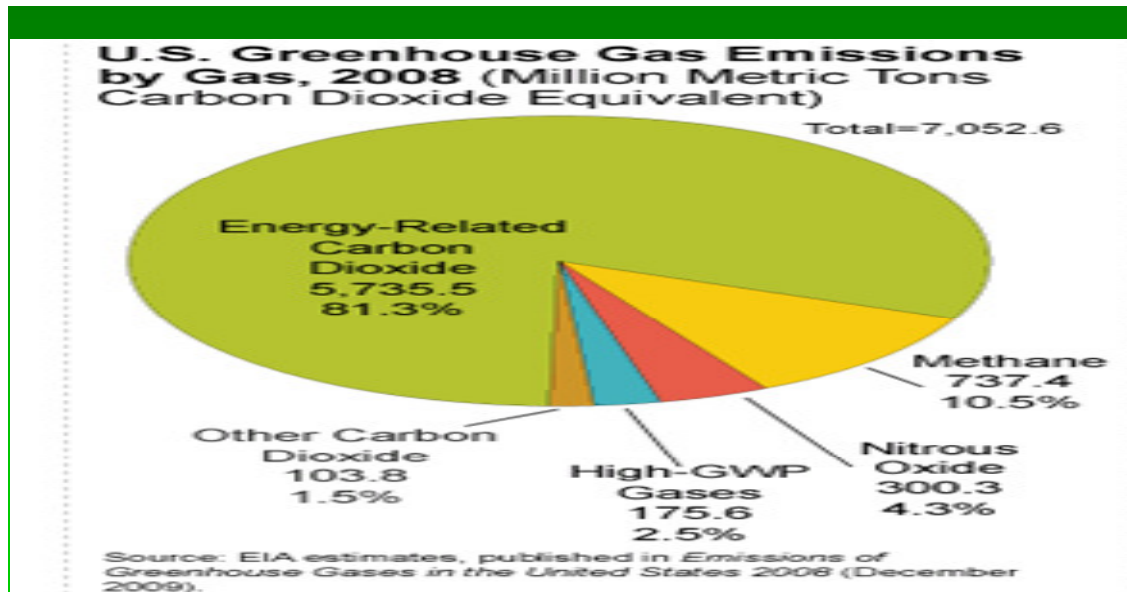


Fig 5.0 US Green house gas emissions

[Wikipedia]

5.4 GERMANY.

According to the Statistic der Kohlenwirtschaft a German coal industry associated ,lignite (brown coal) represents owner 40% of Germany total domestic energy production from which 25% is open coast .In 2003 Germany emitted 842,0 million metric ton of making it the sixth largest emitter of CO_2 in the world. Up to ten coal fires per year in Ruhr (Germany) are caused by spontaneous combustion (Pilarezyk et al 1995)

According to initial calculation by the federal Environment Agency (UBA) total gas emission in Germany at the end of 2009 has declined by – 8. 4% over 2008.The strategy used by German industries was mainly based on efficiency increase by building up new Power Plants and decommissioning older one

5.5 Lessons learned

The spontaneous combustion process is dispersed in almost all countries which use the coal as a fossil fuel for electricity production. The process is present in underground mines and in surface ones .In general not yet any of them has find out the proper way to stop the development of this process. The strategy used from most of them is mainly based on improving technology related with main parameters of process such are detection and monitoring in early stages of development. China is the mostly affected from the process but the huge project is just in phase of development which include experts world wide named as a Sino- German project. It is expected that this project will find out any new direction in the way how to stop the further development of the spontaneous combustion in to the future.

6.0 Conclusions & Discussions.

Giving on consideration to the huge amount of coal reserves not only in current mines but also in new potential fields, it is to expect that the electricity production from coal is still to be the medium alternative and easily achieved because of existing infrastructure. As a result of this strategy in Kosovo the new Power Plant building is just in the final phase of preparation, this will lead in increase of coal consumption but as a part of it the other processes which will accompanied it is going to be spontaneous combustion and CO₂ emissions.

Mainly spontaneous combustion consequences are related with common factors such are poor mine planning, reluctance to acknowledge the seriousness of situations, inadequate information and inadequate training of key decision makers. The effective management of spontaneous combustion relies on modern technology and rapid decision making by skilled and informed workforce but also on preparing a proper strategy on fighting against those processes.

In today's business the value of Company could be measured also by the assets it posses. Having an asset and misusing it or living it unused will decrease the efficiency and the value of organization. New technology will enable the company to develop faster and with successful trends.

The new technology and the new policy making will provide a better opportunity to better manage the current situation. This approach will be built on the information related with:

- Detection
- Monitoring
- Prevention and
- Control of spontaneous combustion

Such data will help on building a new useful strategy with aim to stop the development of process in early phases; otherwise it will be hard to get under control the process.

Applying new technology will help directly on the area defining, strategy which is used in other states affected from the spontaneous combustion process. The methodology proposed will help on blocking almost all possible paths, to avoid the reaction between oxygen and flammable material (coal). This will lead on direct benefits for mine saving a considered coal tonnage but also environmentally will impact positively. But it is still to consider that old methods will be still applicable in different areas when the potential of spontaneous combustion is lower, appears already on surface and it is not so spread, however after the actions is taken the area must start to be monitored permanently with aim to avoid the rapidity of process which is so often

Developing a new approach to the problem solving within the company will lead to further improvements of the company trying to build a new culture of communication between employees. Building both ways of communication not only from the bottom up strategy but also from top-down this will directly affect the growth of the Organization. Strategy building and new procedures should be used on the current mines and is expected to also fit in potential fields. The rest resources of coal in Kosovo can provide annual outcomes of valuable energy. It is there for in everyone's best interests to see potential sources being produced must efficiency from both an economical and environmental perspective

Economically this process is causing a significant loss in mine industry but also environmentally it is impacting not only employers active in mines but also it contribute to global warming by emitting CO₂. The approach proposed to be applied differ from old one first of all because it propose a permanent engagement from all participants. If the process will be properly detected and monitored the possibility to prevent and control it will be higher.

Environmentally new approach will be large friendly then the previous one fighting fire by using water spray a huge pollution activity is going to appear, land sliding and the habitat around will be affected negatively. In the other hand grouting system will not only close most of supplier channels with oxygen but it will also improve the land stability, the new technology will give us on opportunity to directly measure presence of

CO₂ and other gases differently from the previous data which has been mainly estimated data (measurements in mine Bardh and Prishtina city). Measures done in the mine mainly nearby the affected area from spontaneous combustion has shown relatively higher level of CO₂ and CO presence, but those made in Prishtina it seems that are not so far from the average rank based on general guide values for CO₂ emissions.

What is intended to accomplish in this capstone is to evaluate the effectiveness improving for the prevention of spontaneous combustion in Kosovo's Open Mining process, by considering new technology and new approach. This new approach can be evaluated by engaging expert teams, who will apply the new technology. The results obtained in this project will contribute to the assessment of the new technology, economic and environmental values that benefit from it. New approach is expected to

- Enhance safety plans by using the new technology.
- Develop a new approach about prevention of Spontaneous combustion for the Kosovo open mining process.
- Provide useful approach related with potential coal field in Kosovo as much as in current one.
- Showing how to improve air quality by applying new technology.
- Will affect consequently on all actress related with electricity production and environmental pollution.
- Provide economic benefits estimates for using new technology.

7.0 Recommendations

Based on the conclusions from this capstone the main recommendations are:

- To take into account the likelihood of spontaneous combustion when preparing all mining plans and provide adequate planned procedures because it is on every one best interests.
- To identify areas where spontaneous combustion is most serious and arrange appropriate urgent action
- To apply new technology in 2010 for immediate economic and environmental benefit.
- All features and procedures are to be done under the coal mine health & safety regulations. An assessment should be regularly made to confirm the extent to which they are adhered to.
- All procedures should be applied in the existing coal fields and potential Kosovo coal fields.
- To further encourage the exploitation and use of domestic deposits of lignite in environmentally responsible ways because of potential enormous economic gains.

Appendix A

The INKOS Institute was established in 1979. After the process of incorporation and outsourcing from KEK, in 2006 INKOS institute was registered as a joint stock company, INKOS institute j.s.c. is located in Kastriot (Obiliq). Its activity is based on the status approved in 17.02.2006, as an independent institute with full competences in KEK and other interested parties in Kosovo and the region. It was certified by the Ministry of Trade and Industry as: INKOS institute j.s.c. with eight applicative science activities, with a macro organization structure consisting of 6 sectors and with a micro organizational structure consisting of 17 thematic divisions. The specialized roles and functions of the INKOS institute are mainly focused in the energy sector.

INKOS institute provides services for other entities in Kosovo, in accordance with the requirements of the market economy. Its activities are based and implemented in accordance with the laws and sub-laws of Kosovo and EULEX regulations, as well as technical rules, directives and other acts which deal with INKOS institute activities. INKOS institute j.s.c. closely cooperates with Kosovo ministries, University and institutes in Kosovo, EULEX and KFOR, legal and physical entities and also with many other institutes outside Kosovo. INKOS institute j.s.c. trains its staff time after time inside and outside of Kosovo for better quality and efficiency.

Since April 24, 2008 INKOS institute has been certificated by TÜF, a German Academy.

“INKOS” Institute posses a good infrastructure and is a recognized laboratory with ISO 17025/2006 standard.

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